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ABSTRACT

Issues related to the international flow of scientific and technical talent are discussed in these proceedings. The symposium was organized into three panels covering the topics of data, policies, and issues as they relate to the utilization of foreign talent. The panel on data provided information on the number of foreign students in United States colleges and universities, the costs of educating foreign students, and utilization patterns of foreign scientists and engineers. The second panel examined policies, laws, and problems associated with the international flow of talent. The panel on issues presented different viewpoints on faculty shortages, graduate education, the impact of foreign engineers on industry and universities, and the export of U.S. technology from the standpoint of national security. Also included are perspectives from the National Science Foundation, the meeting agenda, a conference summary. Appendices contain a list of symposium attendees and a bibliography of additional information sources. (ML)

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THE INTERNATIONAL FLOW OF SCIENTIFIC TALENT: DATA, POLICIES AND ISSUES

Proceedings

of the

1965 Joint Meeting of the Scientific Manpower Commission
and the Engineering Manpower Commission

NATIONAL ACADEMY OF SCIENCES
Washington, DC

May 7, 1965

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Julie A. Early

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SCIENTIFIC MANPOWER COMMISSION - ENGINEERING MANPOWER COMMISSION

AGENDA

THE INTERNATIONAL FLOW OF SCIENTIFIC AND TECHNICAL TALENT: DATA, POLICIES AND ISSUES

Lecture Room, National Academy of Sciences
2101 Constitution Avenue, N.W., Washington, D.C.
May 7, 1985 - 9:30 A.M.

9:30 am Welcome and Introduction of Subject - Joy Stapp, President, SMC

9:40 Perspectives from the National Science Foundation (NSF)
Richard Nicholson, Staff Director, NSF

10:00 Panel Discussion on Data - Beverly Porter, American Institute of Physics, Moderator

Elinor Barber - Institute of International Education
Joel Barries and Mary Golloday - NSF
Michael Finn - Oak Ridge Associated Universities
Bill Aldridge - National Science Teachers Association

11:00 Break

11:15 Panel Discussion on Policies - Alan Fechter, National Research Council, Moderator

Mary Gray - American University
Jack Doyle - Institute of Electrical/Electronics Engineers
Bud Green - General Electric
Lucius Walker - Howard University
Gwen Robosson - Fragomen, DelRey & Bernsen
Michael Nacht - University of Maryland
J. Chester McKee - National Research Council

12:15 Lunch Break. (Lunch is not provided. Attendees may use the cafeteria at the Academy if they wish.)

1:30 Panel Discussion on Issues - Richard Wilcox, U.S. Arms Control and Disarmament Agency, Moderator

John Hamblen - University of Missouri-Rolla
Jack Doyle - Institute of Electrical/Electronics Engineers
Roberta Hall - Project on the Status and Education of Women, AAC
Maurice Mountain - Consultant
Robert Morgan - Washington University

2:30 General Discussion - Joy Stapp, Moderator

3:15 Conference Summary - Charles Falk, Consultant

3:30 Adjournment

THE INTERNATIONAL FLOW OF SCIENTIFIC AND TECHNICAL TALENT: DATA, POLICIES AND ISSUES

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THE INTERNATIONAL FLOW OF SCIENTIFIC AND TECHNICAL TALENT: DATA, POLICIES AND ISSUES

A Symposium Sponsored by the Scientific and Engineering Manpower Commissions

Lecture Room, National Academy of Sciences
2101 Constitution Avenue, N.W., Washington, D.C.
May 7, 1985

Welcome and Introduction - Joy Stapp, President, Scientific Manpower Commission

This symposium is the Joint Annual Meeting of the Scientific and Engineering Manpower Commissions. Because of the wide interest in the topic, we have invited many of you who are from outside the Commissions and we welcome you.

The symposium has been organized into three panels covering the topics of data, policies and issues, as they are related to the utilization of foreign talent.

The first panel will present some of the recent data and suggest what some of the data needs may be. The second panel will examine policies which affect the international flow of talent and the third panel will discuss the issues.

The issues are complex and may be discussed from a variety of perspectives. The purpose of the symposium is not necessarily to provide answers, but to present these different perspectives, examine the issues and formulate questions for further exploration.

Perspectives from the National Science Foundation - Richard Nicholson, Staff Director, NSF

The National Science Foundation has always monitored and maintained databases on science and engineering research and development personnel, as mandated in the National Science Foundation charter. The group in the Foundation responsible for this data collection, analysis and dissemination is referred to as the Division of Science Resources Studies (SRS).

SRS is the group providing most of the data used to examine the status of science and engineering in the U.S. and abroad. It is the key organization maintaining data on foreign scientists and engineers, graduate students and doctoral recipients. SRS also works collaboratively with other government agencies as appropriate, such as the Bureau of Labor Statistics (BLS, Department of Labor) and the Immigration and Naturalization Service (INS, Department of Justice) in collecting data.

The Division provides grants to individuals and organizations to conduct studies and collect data. Elinor Barber (Institute of International Education) and Michael Finn, (Oak Ridge Associated universities) for instance, have received funds from SRS.

Because of the increased interest in this topic, including interest demonstrated by the new NSF director, Erich Bloch, and the interest reflected in the relatively new National Academy of Sciences roundtable, NSF has become even more active in gathering

information on foreign scientists in the U.S. SRS has responded by preparing the report, distributed at the beginning of this meeting, entitled Participation of Foreign Citizens in U.S. Science and Engineering, a useful compendium of information.

The topic of the utilization of foreign talent has generated interest among several of the foremost scientific organizations, many of whom are represented here today. As mentioned earlier, both Erich Bloch and the National Academy's Industry/Government/University Roundtable - a new organization, chaired by Dale Corsun, that the Academy developed about a year ago to act as a forum for the three groups - have a specific interest in the issues related to foreign students.

Other indications of the growing interest are the discussions on Capitol Hill and the creation of the Committee on International Science by the National Science Board. Moreover, the National Academy now has an annual publication called Outlook For Science And Technology and one issue was devoted entirely to this subject.

Why is this topic important to consider? The fact that over one-half of the U.S. Ph.D.s in some fields are earned by foreign nationals has brought greater attention to the education of foreign nationals. The U.S. has always welcomed students from abroad, playing the role of "schoolhouse to the world." Not too long ago this country was composed almost entirely of a population of foreign nationals. In the view of the majority of the population, this has been considered a positive gesture, something this country should do which, in turn, provides benefits to us. The current change in attitude results from the rise in the percentage of Ph.D.s being awarded to foreign nationals. Let us first look at the advantages.

On balance, the U.S. benefits from the flow of international talent into its colleges, universities and research institutions and has been successful at attracting highly talented individuals, many of whom perform better on GREs than U.S. students. These foreign students, in turn, satisfy the supply and demand at colleges, universities and industry where there are increasing shortages of persons to fill all of the available positions. Without this additional source of labor, or personnel, many industries would suffer.

Another benefit is that those foreign students who return home after a U.S. education often enter into positions of leadership in their countries where they have proven to be good ambassadors. Students and alumni form a positive network for information exchange between nations. The National Science Board states that this country can only benefit from this two way interchange and that restrictions on the utilization of foreign talent should be removed.

Yet there are disadvantages associated with this flow of talent into the U.S. One is the "brain drain" in which the loss of talented individuals has a negative impact on their home countries - particularly when they are developing countries - when students do not return. One hears of the potential threat that technology transfer poses, although according to NSF this is not as major an issue. It is raised as a concern in some fields more than others, but overall, it is not a significant problem.

Another disadvantage that is often mentioned is that foreign teaching assistants with language difficulties present problems for the undergraduates they teach and that these unfavorable learning experiences may subtly discourage U.S. students from pursuing advanced degrees. Still another concern is that the availability of bright foreign nationals may cause universities to be less aggressive in their recruitment of U.S. students. Some of the decline in the number of Ph.D.s in science and engineering awarded to U.S.

students may be attributed to this. The decline, in some cases, has been more than compensated for by foreign students, but how to view this compensation is an issue to consider here. The issue may be best defined as how the U.S. can increase the numbers of its own students in graduate schools, rather than how the number of foreign nationals can be decreased.

The Committee on International Science of the National Science Board stated (January 1985) that it found no disadvantages to the U.S. from foreign nationals now comprising almost 25%, and up to 50%, of graduate schools and faculties of U.S. engineering schools. Without the services of these foreign nationals, the U.S. would be unable to educate its own engineers. The Committee is more concerned that too few U.S. students are competing for those positions in graduate schools than with the high numbers of foreign students obtaining engineering degrees. The steady decline in the number of U.S. students pursuing science and engineering at the graduate level and the decline in the number entering academic careers is definitely a concern. These numbers are significant in that they reveal that the U.S. will have a problem educating its own students without the assistance of foreign nationals. The need is critical if we are to ensure that there are teachers to train the next generation of scientists and engineers. For that, in turn, will affect the future of U.S. industries.

Universities benefit, nevertheless, by admitting students from abroad. With the number of students entering colleges and universities declining, institutions of higher education are seeking ways to supplement their student bodies in order to remain open.

Return on the U.S. investment in the education of foreign students is being restricted by laws limiting the number of these students that can be employed by U.S. industries upon their graduation. The Committee therefore supports the enactment of legislation, or amendments to current legislation, which will reduce the restrictions on the hiring of foreign nationals. The health of U.S. science and engineering is critically dependent upon U.S. immigration policy, according to this committee of the National Science Board.

Issues of national security, created by communication among U.S. citizens, foreign students and alumni, are concerns of various officials. In addition, the future strength of U.S. industries is dependent upon greater utilization of U.S. students. Yet until this can be assured, restrictions on foreign scientists, such as those imposed by U.S. immigration policy must be removed. The declining size of the eighteen year old population in the U.S. (25% over the next ten or fifteen years) also calls for some policy changes in order to compensate for this loss of scientific manpower.

Discussion

Have financial support statistics for students and scientists been collected by NSF? In FY86 NSF will begin to collect this information through grants to researchers. This information will be broken down into amounts allocated for graduate students and post-doctoral students on the individual grant. Data specifically looking at women, minorities and disabled persons also will be examined more closely through final reports of grantees beginning in FY86.

Penny Foster, National Science Foundation

Over the years there has been a perception that foreign students are supported by the U.S. government but that has been proven inaccurate. According to IIE statistics, only two percent of all foreign students in U.S. institutions receive any form of federal funding; most are self-supported. This is presumed to be the case for graduate science

and engineering students as well. The overall perception is that foreign students are supported by their families. That is what we read in the literature. However, this does not mean that individual foreign students enrolled in science and engineering are not supported on research grants in some way. It does mean that NSF only grants fellowships to U.S. citizens. And other federal agencies may only allow their fellowship funds to be used for U.S. citizens.

Lee Grodzins, Massachusetts Institute of Technology

Although there was a time when NSF collected such information, looking specifically at first year graduate students, that stopped ten years or so ago. If one goes back to the early 1970s, it is possible to find data on who supported what. The information now being collected is not going to satisfy the people who want the data because a large number of the foreign nationals, especially the first year students, are being supported by teaching assistantships, not just research assistantships. The language difficulty is, of course, a problem. However, there are teaching jobs, such as grading papers, that do not require standing in front of a classroom. And this is how a number of people are being supported, particularly foreigners entering the sciences and engineering.

Foreign students, especially in engineering, are being supported primarily by teaching and research assistantships. Many students at large state universities receive their funding this way. There is definitely a need for a more comprehensive database. Foreign nationals are important in that they comprise, for example, approximately 40% of first year graduate students in physics and over 50% of physics postdoctorates.

Charles Falk, Consultant

You could access the first year data, but NSF never collected data on specific financial support of foreign students even then. About a year ago, NSF began collecting data on a sampling basis, not a universe basis. This means that you are talking about relatively small cells and that makes the problem of obtaining the correct information even greater.

Alan Fechter, National Academy of Sciences

The Academy has a database which can tell you where doctorates are receiving their support. What we don't have is comprehensive information. Where are various types of students - undergraduate, graduate and postdoctorate - receiving their support? There is a serious gap in the information which goes beyond NSF.

Panel Discussion on Data - Beverly Porter, American Institute of Physics, Moderator

Elinor Barber - Institute of International Education
Foreign Students in U.S. Colleges and Universities: Data

Joel Barries and Mary Golloday - National Science Foundation
Available and Unavailable Data

Michael Finn - Oak Ridge Associated Universities
U.S. Utilization of Foreign Scientists and Engineers

Bill Aldridge - National Science Teachers Association
Costs of Educating Foreign Students

Beverly Porter, Moderator, American Institute of Physics

Foreign nationals have long played a major role in the development of science and engineering in the U.S. In fields such as physics, where foreign nationals have come to represent 40% of the first year graduate students and over half of those at the post-doctoral level, their leverage and potential impact on the future can be major.

Other panels later today will discuss the variety of issues which an increasing foreign component raise. We will first look at what data we have and what further information is needed to understand the basic dimensions of the international flow of scientific and technical talent.

Consistent and reliable data in this area are not easy to obtain; many - sometimes crucial - gaps in the information exist. Our panelists this morning will discuss the data which are or will be available and what basic information is still missing.

Elinor Barber, Institute of International Education

Foreign Students in U.S. Colleges and Universities: Data

The Institute of International Education (IIE) has a research unit that collects data on the flow of foreign students to the United States. These data may be used in studies of policy issues, e.g., the impact of foreign nationals on higher education in this country or, specifically, the meaning of foreign engineering students for U.S. science and engineering and for U.S. industries.

In assessing the total flow of talent, it is important to examine the component that has its origins overseas. Major areas to examine include: what foreign students are studying, in what numbers, and at what level; the extent to which foreign students raise or lower the quality of the student body in universities, overall or in particular fields; whether there are cultural differences between the ways in which science and technology are carried on in the United States and in the foreign students' home countries; the degree to which foreign students' preparatory training is suitable for their further in the United States; and the cost of foreign students to U.S. institutions of higher education.

IEE conducts two surveys. The first is an annual survey of institutions in the United States, enumerating full-time enrolled foreign students by country of origin, academic characteristics (field of study, academic level), and personal characteristics (sex, marital status, primary sources of funds, visa types). The data are provided by campus officials, primarily foreign student advisors and, to a lesser extent, registrars. The results of this survey are published in Open Doors. Over 95% of the institutions surveyed respond, so that Open Doors contains, in effect, a census of the foreign student population. To obtain this very high response rate, institutions are asked to provide only aggregate data, which means that these data cannot be cross-tabulated. It is possible to find out from Open Doors how many Nigerians there are studying in the United States and how many foreign students are studying engineering, but not how many of the Nigerian students are undergraduate and graduate engineering students.

IIE's second survey, which is conducted biennially, collects data on individual foreign students, which permit the kinds of cross-tabulations that cannot be done with Open Doors data. The second survey, called Profiles, yields responses from 75% of the

Table 1

Origin of foreign students within fields of study, 1983/84

	WORLD REGION								
	Africa	Europe	Latin America	Middle East	North America	Oceania	South & East Asia	Total	# Of Students Reported
Agriculture	26.6	5.5	27.9	8.7	4.1	1.0	26.3	100.1	4,993
Business and Management	16.1	8.6	17.8	12,3	4.2	1.3	39.7		37,939
Education	16.5	9.7	17.1	13.2	10.8	4.1	28.7		7,944
Engineering	7.0	6.5	12.22	30.1	1.8	0.2	42.2		43,261
Fine and Applied Arts	15.8	6.5	21.2	16.5	4.8	0.5	34.5		4,185
Health Sciences	16.5	9.9	18.8	14.3	9.8	2.3	28.4		8,814
Humanities	9.6	21.4	14.4	6.8	9.7	2.5	35.6		8,490
Math/Computer Science	6.4	7.1	13.0	17.2	1.5	0.7	54.1		18,993
Physical/Life Sciences	10.6	11.4	12.8	14.3	4.3	0.9	45.7		15,888
Social Sciences	6.8	16.4	18.2	10.7	11.0	2.1	34.8		7,739
Other	14.4	12.9	17.8	11.1	7.5	1.6	34.7		7,400
Intensive English Language	2.9	5.4	22.5	26.5	0.5	0.0	2.0		3,296
Undeclared	10.3	16.1	19.1	12.8	9.3	1.3	31.2		8,108
All Fields	11.4	9.6	15.8	17.4	4.8	1.2	39.9		177,050

Table 2

Field Of Study For Foreign Students According To World Region Of Origin, Field Of Study, and Academic Level.

UNDERGRADUATE

World Region/ Leading Countries (In 1983 /84)	Agri	Bus Mgmt	Educ	Engr	Fine Arts	Health Sciences	Humanities	Math/ Comp Sci	Phys/ Life Sci	Social Sciences	Other	English	Undeclared	# Of Foreign Students Reported
Africa	4.7	36.9	4.4	13.9	3.5	7.4	2.2	6.3	6.8	2.6	5.5	.1	5.6	11,676
Nigeria	5.2	46.5	5.6	8.2	5.0	7.1	1.4	3.4	5.1	2.7	5.9	.0	3.9	6,165
Egypt	.0	18.3	1.4	42.7	2.0	5.4	1.4	9.5	7.5	2.4	1.7	.0	7.8	295
Ethiopia	1.1	21.2	1.8	12.4	.8	14.7	1.5	14.8	10.6	1.3	4.2	.3	15.2	613
Kenya	7.6	36.4	4.8	10.9	2.5	6.7	1.5	6.3	8.0	2.1	7.0	.1	6.1	671
Libya	.4	11.2	.7	44.8	1.8	.4	1.3	18.8	9.4	4.9	2.5	.0	3.6	446
Europe	1.2	23.8	5.5	16.3	1.5	4.1	7.5	7.6	7.0	7.8	5.6	.2	11.7	8,130
United Kingdom	1.4	23.5	10.4	11.6	1.7	4.4	7.2	7.0	6.4	6.7	6.9	.0	12.8	1,619
Greece	.4	18.7	2.3	33.4	1.5	2.6	3.9	12.7	10.0	6.2	2.1	.4	5.8	1,266
Germany,Fed Rep	2.0	19.5	3.8	8.8	2.1	4.2	13.5	4.7	9.8	10.3	4.9	.3	16.0	793
France	.9	27.0	2.0	9.8	1.4	2.7	11.9	8.4	6.6	8.4	6.4	.5	14 0	655
Norway	.5	31.3	2.9	33.4	.4	2.8	1.8	4.6	2.1	6.3	5.8	.0	8.2	796
Italy	1.1	28.8	2.4	13.2	2.4	1.9	8.1	6.5	6.2	10.2	6.2	.5	12.4	371
Latin America	3.4	27.6	3.8	19.4	3.7	6.0	3.2	9.8	5.8	5.5	4.7	.3	6.8	18,862
Venezuela	3.4	26.7	3.1	27.3	4.7	2.6	1.7	12.8	4.8	5.7	3.6	.2	3.6	5,051
Mexico	6.6	25.0	4.4	14.3	2.9	3.1	7.3	8.7	4.9	9.4	5.5	.4	7.6	1,212
Colombia	6.7	26.3	3.8	17.6	3.6	6.2	3.0	8.6	5.0	6.6	5.0	.2	7.2	1,612
Brazil	2.2	20.0	5.6	13.3	1.8	5.0	7.9	11.3	5.4	11.3	5.4	.7	8.8	556
Jamaica	5.2	28.2	3.8	10.8	2.4	9.3	3.3	8.8	9.9	3.7	8.0	.0	6.8	873
Middle East	.8	17.0	1.1	47.1	2.2	4.0	1.2	10.9	6.4	2.7	2.5	.2	4.1	19,304
Iran	1.8	8.0	1.1	42.0	2.5	7.5	.9	13.5	13.8	2.1	2.8	.1	4.1	6,008
Saudi Arabia	.3	28.9	1.3	34.9	1.9	1.9	1.9	12.2	2.9	7.2	2.8	.2	3.5	2,464
Jordan	.5	14.0	.6	63.4	2.2	2.8	.9	8.3	1.7	1.3	.8	.2	3.4	2,637
Lebanon	.3	13.4	.4	61.1	2.9	3.8	.7	7.3	2.6	1.1	2.2	.2	4.0	2,527
Kuwait	.8	26.8	1.9	48.9	1.1	.9	.9	10.2	1.6	1.3	2.1	.1	3.5	1,394
North America	2.1	21.6	11.1	11.5	2.5	8.4	5.8	3.6	5.9	9.6	6.4	.0	11.7	4,796
Canada	2.2	21.0	10.9	11.9	2.5	8.0	5.8	3.5	5.9	9.8	6.4	.0	12.0	4.554
Pacific Islands	.9	35.0	18.2	3.8	.8	8.0	2.6	6.0	4.7	6.9	5.0	.0	8.2	1,128
Oceania	1.0	41.9	19.2	3.1	.4	9.2	1.0	5.7	4.8	2.7	4.0	.0	7.1	731
Australia	.0	20.8	21.7	5.4	2.5	5.8	5.0	3.8	2.1	15.8	6.3	.0	10.8	240
South and East Asia	.6	26.4	2.2	24.8	2.8	3.5	3.3	16.0	5.2	5.0	3.4	.3	6.5	30,298
Taiwan	.4	21.0	2.4	22.4	2.2	5.2	2.4	23.8	5.6	4.6	5.5	.0	4.4	2,345
Malaysia	1.4	24.7	1.5	33.1	5.7	1.1	2.7	16.6	5.8	1.0	2.0	.0	4.4	7,113
Korea, Rep. of	.3	25.8	2.9	14.0	2.0	2.9	6.0	13.8	6.2	11.7	3.9	1.7	8.9	1,956
India	.4	21.0	1.5	28.6	.9	6.2	2.2	17.5	6.6	3.0	3.5	.0	8.6	1,610
Japan	.6	25.2	5.6	4.8	1.7	3.1	11.2	9.3	4.7	14.3	6.3	.7	12.4	3,367
Hong Kong	.2	34.9	1.4	21.3	2.4	3.9	.9	17.1	4.7	4.9	3.2	.0	5.3	3,219
ALL REGIONS	1.9	25.7	3.5	25.3	2.8	4.9	3.2	11.0	6.0	4.8	4.1	.2	6.7	94,194
Number Of foreign students reported														

Table 3

Field Of Study For Foreign Students According To World Region Of Origin, Field Of Study, and Academic Level.

GRADUATE

World Region/ Leading Countries (In 1983 /84)	Agri	Bus Mgmt	Educ	Engr	Health	Fine Arts	Scien ces	Human- ities	Math/ Comp Sci	Phys/ Life Sci	Social Sciences	Other	English	Un- Declared	# Of Foreign Students Reported
Africa	11.3	19.2	10.7	16.3		3.0	6.7	7.5	5.2	11.4	2.5	5.3	.1	.9	6,594
Nigeria	7.2	33.3	14.3	10.3		4.0	6.5	4.6	2.5	7.5	2.4	6.1	.0	1.1	2,358
Egypt	7.1	9.3	5.4	30.8		2.9	10.4	4.8	7.3	15.4	1.9	3.6	.2	.9	892
Ethiopia	13.8	13.1	8.8	6.3		2.5	5.0	10.6	8.8	19.4	5.0	5.0	.0	1.9	160
Kenya	20.6	15.8	12.1	6.3		1.8	7.0	11.0	3.3	11.4	1.5	9.2	.0	.0	272
Libya	10.4	5.7	11.4	30.0		3.6	5.0	1.4	9.6	16.1	3.6	2.1	.4	.7	280
Europe	2.4	15.0	3.6	18.0		1.6	7.3	15.8	8.6	15.6	5.1	5.9	.0	1.0	6,381
United Kingdom	2.0	13.7	5.7	11.9		2.0	7.8	15.7	6.8	18.5	8.1	7.0	.0	.6	1,122
Greece	2.4	15.1	2.5	37.9		2.2	4.1	4.1	9.5	17.5	1.9	2.2	.0	.5	918
Germany, Fed Rep	1.8	10.8	2.2	11.4		1.7	8.3	22.3	10.7	17.3	4.9	7.0	.1	1.4	831
France	1.7	24.2	1.2	21.1		1.9	8.5	18.5	3.7	8.7	3.3	6.5	.0	.7	828
Norway	2.8	28.5	8.3	25.0		.0	.7	11.1	5.6	8.3	5.6	2.8	.0	1.4	144
Italy	1.7	9.2	1.1	10.9		1.7	7.0	23.3	14.4	18.1	6.0	4.9	.0	1.4	348
Latin America	11.2	15.7	8.9	19.1		1.8	6.5	8.4	6.4	12.5	3.2	5.5	.0	.7	6,313
Venezuela	6.2	19.9	14.5	20.8		2.2	5.2	4.1	6.7	11.5	2.2	5.7	.0	1.0	1,125
Mexico	13.0	18.8	7.8	20.0		1.3	5.1	5.6	6.6	13.3	2.2	5.2	.0	1.1	1,188
Colombia	7.4	18.6	6.1	20.0		2.3	7.0	11.0	6.7	10.6	3.2	6.7	.0	.4	526
Brazil	14.3	9.8	8.7	21.8		1.8	3.8	9.7	6.0	12.9	6.3	4.5	.2	.1	838
Jamaica	5.7	11.8	16.7	7.0		.4	20.2	15.8	2.6	7.9	2.2	9.2	.0	.4	228
Middle East	3.3	10.8	9.6	38.3		2.3	5.4	3.1	9.4	11.0	2.3	3.8	.0	.8	7,767
Iran	2.3	7.2	5.8	48.4		2.6	3.8	1.6	11.1	11.0	1.4	3.5	.0	1.0	3,256
Saudi Arabia	4.5	14.9	23.8	21.4		2.8	2.7	4.5	6.8	9.8	2.4	5.9	.1	.3	777
Jordan	2.2	11.6	14.2	25.9		1.7	9.2	7.0	8.6	12.7	1.7	4.4	.2	.7	544
Lebanon	1.7	10.7	3.4	55.1		2.9	6.6	2.6	5.8	5.8	1.1	3.7	.0	.6	652
Kuwait	1.3	26.4	23.9	14.5		.6	10.7	2.2	7.9	5.3	3.1	3.5	.3	.3	318
North America	2.7	12.3	9.8	7.6		2.3	13.2	18.5	3.2	12.9	9.8	6.5	.0	1.1	2,620
Canada	2.8	12.4	9.5	7.6		2.3	13.2	18.6	3.2	12.8	10.0	6.5	.0	1.1	2,587
Pacific Islands	4.5	8.1	11.8	5.8		1.4	13.6	22.0	6.9	11.4	6.8	7.3	.0	.4	737
Oceania	.0	16.1	19.4	.0		.0	38.7	.0	.0	12.9	3.2	9.7	.0	.0	31
Australia	3.7	7.4	13.4	5.4		1.4	11.4	24.0	7.4	10.9	7.4	7.2	.0	.6	516
South & East Asia	3.3	15.8	4.3	30.0		1.5	3.9	5.4	12.5	15.9	2.7	4.1	.2	.5	32,011
Taiwan	2.7	10.8	4.2	35.7		1.4	3.5	2.6	18.2	14.6	2.4	3.5	.1	.3	9,189
Malaysia	8.3	35.0	7.7	16.0		1.8	2.8	4.4	8.2	9.8	1.4	4.1	.0	.5	1,323
Korea, Rep. of	2.0	17.3	4.5	29.9		2.1	1.8	9.7	7.6	14.3	4.8	4.6	.8	.5	4,301
India	1.5	15.5	1.6	39.7		1.0	3.5	3.4	13.4	16.8	.6	2.8	.0	.3	5,688
Japan	2.1	21.3	7.5	14.0		1.7	7.5	15.5	5.2	9.4	7.6	6.9	.4	1.0	1,862
Hong Kong	.7	24.5	2.3	24.2		3.0	6.4	7.0	12.7	12.5	3.4	3.1	.0	.3	1,522
ALL REGIONS	4.8	15.2	6.4	26.0		1.8	5.5	7.4	9.8	14.3	3.3	4.7	.1	.7	62,423
Number Of foreign students reported															

Table 4

Fields of study of foreign students within academic levels

FIELD OF STUDY	ACADEMIC LEVEL			
	UNDERGRADUATE	GRADUATE	OTHER	ALL LEVELS
Agriculture	1.9	5.0	.9	3.1
Business/Management	25.4	15.0	8.6	20,8
Education	3.5	6.4	1.7	4.5
Engineering	24.8	25.9	6.7	24.5
Fine and Applied Arts	2.8	1.8	1.0	2.4
Health Sciences	4.9	5.7	2.2	5.1
Humanities	3.1	7.4	5.2	4.8
math/Computer Sciences	10.9	9.8	3.7	10.2
Social Sciences	5.9	14.2	3.1	8.9
Other	4.7	3.2	9.3	4.3
Intensive English Language	4.1	4.7	2.2	4.2
Undeclared	.2	.1	44.5	1.9
Total	7.8	.7	10.9	5.2
Number of Students Reported	99,398	65,651	6,711	171,760

Table 5

Sex of foreign students within fields of study

Field of Study	SEX Male	Female	Number Of Students Reported
Agriculture	83.5	16.5	4,938
Business and Management	71.2	28.8	33,834
Education	52.5	47.5	7,511
Engineering	92.5	7.5	38,248
Fine and Applied Arts	70.8	29.2	3,644
Health Sciences	49.3	50.7	8,460
Humanities	55.9	44.1	7,695
Math/Computer Science	70.9	29.1	16,746
Physical/Life Sciences	72.3	27.7	14,172
Social Sciences	56.5	43.5	6,857
Other	51.4	48.6	7,022
Intensive English Language	65.3	34.7	2,674
Undeclared	62.3	37.7	8,654
ALL FIELDS	71.9	28.1	160,455

Table 6

Distribution of foreign students in engineering subfields

ENGINEERING SUBFIELDS	PERCENTAGE OF ENGINEERING STUDENTS	PERCENTAGE OF FOREIGN STUDENTS	NUMBER OF FOREIGN STUDENTS REPORTED
General	17.9	4.0	8,991
Chemical	5.4	1.2	2,703
Civil	13.4	3.0	6,731
Electrical	20.7	4.6	10,401
Industrial	4.0	.9	2,002
Mechanical	11.6	2.6	5,806
Other Engineering*	16.2	3.7	8,211
Engineering	10.8	2.4	5,410
All Subfields	100.0	22.4	50,225

the institutions surveyed, covering about 65% of all foreign students (approximately 225,000 students.) Profiles data are, however, representative of the entire foreign student population. The accompanying tables are from Profiles.

Table 1 deals with the geographic origin of the students. Geographic origin per se does not tell anything about the quality of foreign students, and in assessing the flow of talent, quality is likely to be the more important variable.

The region supplying the largest component of the flow of foreign engineering students is South and East Asia; 42%, or in absolute numbers more than 18,000, foreign engineering students come from that region. The second largest component comes from the Middle East.

There are data on the academic level of the engineering students from different countries. The country with the leading number of undergraduate engineering students is Nigeria (Table 2). Several countries of the Middle East also send many undergraduates: for countries like Jordan and Lebanon, engineering students comprise over 60% of all the undergraduates they send.

Table 3 presents information on country of origin of engineering students at the graduate level. The countries sending very high numbers are Taiwan (over 3000), followed by India and Iran.

In absolute numbers, there are more foreign undergraduates in engineering than graduate students, but because there are so many American undergraduate engineering students, the foreign students consitute a relatively small proportion of the total: the opposite is true at the graduate level. In absolute numbers, there are about 25,000 undergraduates and 17,000 graduate students in engineering (Table 4). The foreign engineering student body is composed 92.5% of men and 7.5% of women (Table 5).

Profiles contains data on subfields of engineering. These data reveal that electrical engineering attracts the highest number of foreign nationals (Table 6).

At a conference held a little over a year ago, the subject of policymaking at U.S. universities regarding foreign students was discussed. The conference resulted in the publication of Foreign Student Flows. Dr. Lewis Solmon, an economist at the University of California at Los Angeles, prepared a paper for the conference in which he disaggregated the data on foreign student flows by type of institution and field of study and related them to flows of U.S. students. He found, for example, that in 1982, 7.4% of undergraduate engineering students were foreign, as were 42.6% at the graduate level. Solmon also examined the extent of foreign student enrollment at institutions providing relatively large subsidies and in such fields as science and engineering that are expensive to teach, concluding that foreign students are overrepresented in both categories. Foreign students are subsidized especially at the undergraduate level. Another of Solmon's findings refutes the optimistic notion that foreign students will fill the classrooms left half-empty by the dearth of U.S. students: in fact, the fields the foreign students want to study are the same fields that U.S. students want to study.

Mary Golloday, National Science Foundation

Available and Unavailable Data

NSF's Science Resources Studies Division is engaged in an ongoing effort to collect data on foreign nationals in U.S. science and engineering. They are doing more mining, or analysis, of the data they have collected. A more detailed, comprehensive report is expected in the future.

Based on the information and experience of SRS to date, it has been found that the sources of these statistics are numerous and include such places as the Office for Civil Rights, the National Center for Education Statistics (NCES), the very important Institute for International Education, the College Board, the Immigration and Naturalization Service, the Engineering Manpower Commission and so forth. The good news is that there are many sources; the bad news is that the data from these sources do not completely agree with one another and that there are areas lacking adequate information. In some cases, the lack of data may be attributed to the fact that some data are more difficult to obtain. It is not that it is a new idea to look at how students are financing their education, but it is still difficult to obtain that kind of information for the majority of students.

There are some important findings derived from the available data. First, and most important, is that the phenomenon of foreign participation at academic institutions, as well as in the labor force, is a very focused one. Thus, the more generalized the statement about foreign participation the less useful it will probably be. Foreign participation is concentrated in certain disciplines and in certain institutions. One can also look at countries of origin, etc. For data collectors, these present increasingly complex sets of problems.

It is very hard to get the kind of answers that one wants. When looking at charts, the tendency is always to want more detail, more disaggregation and more breakouts. Additional charts have been added to SRS materials since January. The total phenomenon of foreign enrollment has increased dramatically, as the IIE data demonstrate, since these collections began. The latest data show that at all levels the total figure is 333,000. In 1983 the numbers began to level out due to the drop in Iranian students, but the numbers are still rising.

Figure 1 shows growth over time in the number of graduate students enrolled in the sciences and engineering. Changes in the absolute numbers should be examined

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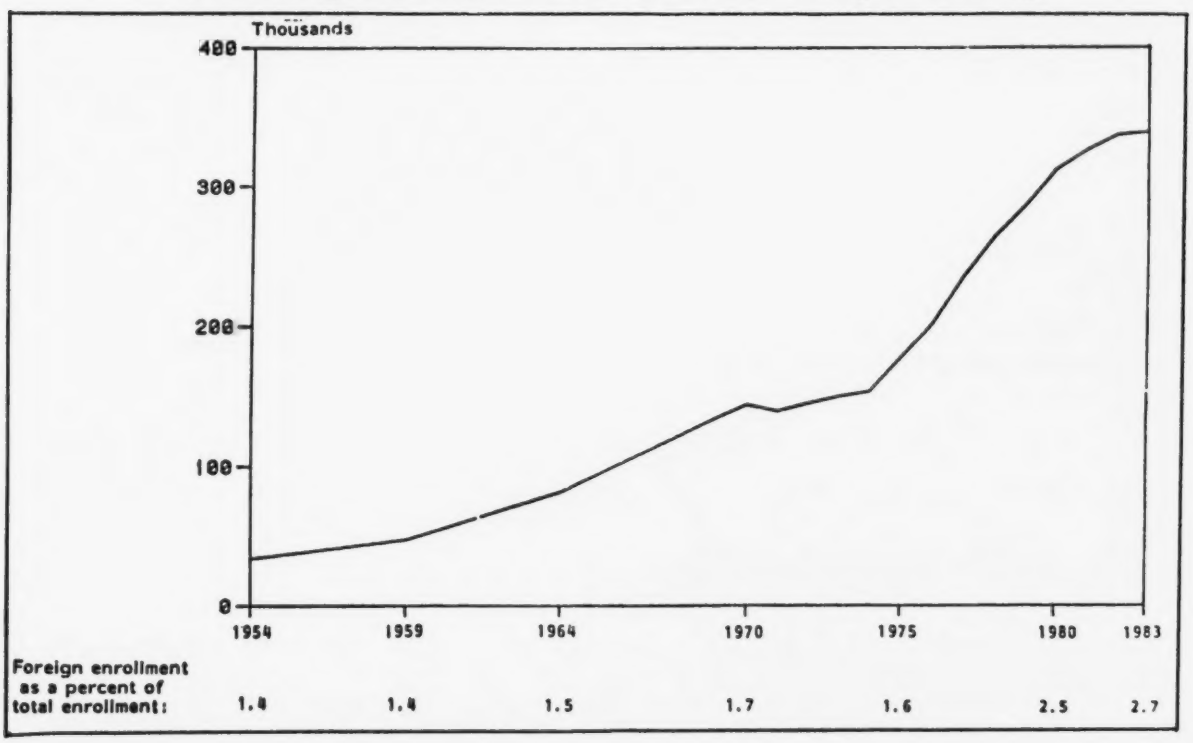
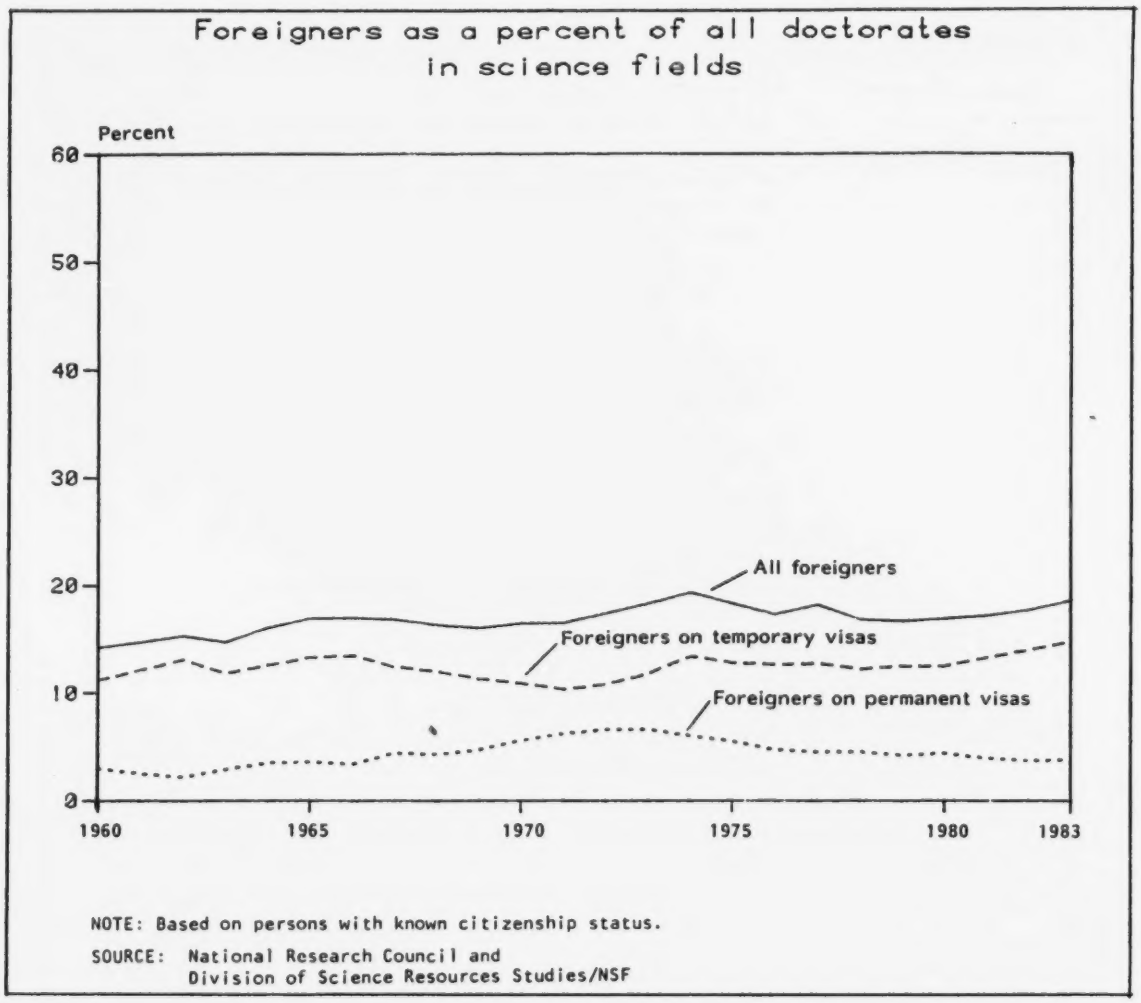
Total Foreign Enrollment in U.S. Institutions of Higher Learning



NOTE: Includes students at all levels. SOURCE: Inst. of Intl. Educ. & NCES

together with changes in proportional levels since the problems are multi-dimensional. The data show that the number of foreign students studying science and engineering in the U.S. has been increasing. Another chart in the compendium provided shows the proportional changes which are not as dramatic.

The proportion of aliens receiving degrees is greater at the Ph. D. than at the master's level which is, in turn, greater than at the baccalaureate level. The largest numbers of degrees being awarded to foreign nationals are in the sciences and engineering. Over 50% of engineering Ph.D.s are awarded to foreign nationals. Figure 2 presents information on foreign students at the point of receiving their doctorates. The two groups represented are those on temporary visas and those on permanent visas. NCES collects information on temporary visas only.

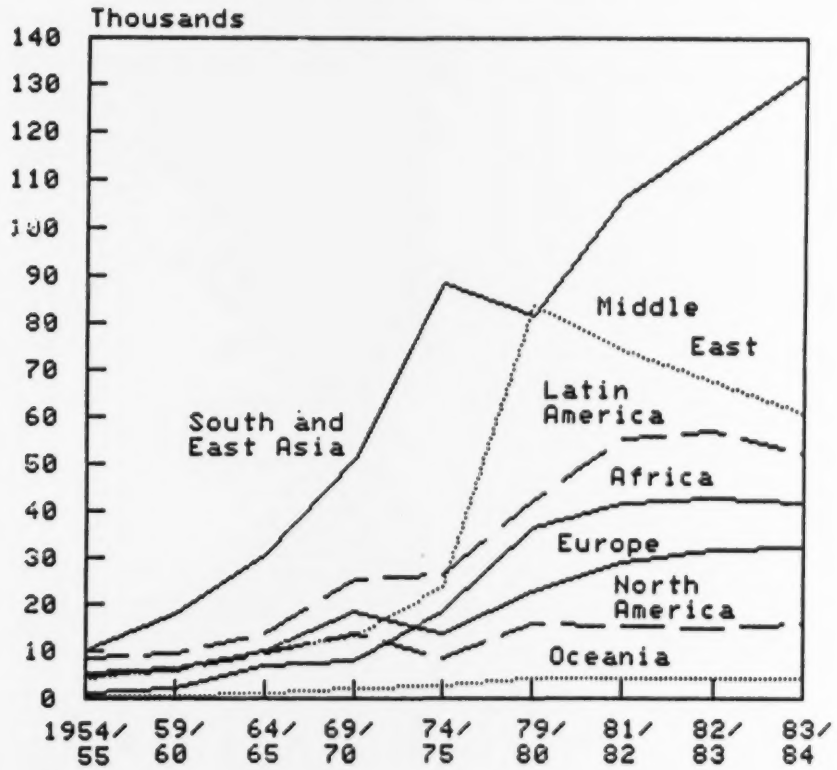


Foreign, as a percentage of all doctorates in science and engineering, has remained reasonably level. The choices made by foreigners on permanent visas parallel those of U.S. students. The strong increase of foreigners in engineering can be totally attributed to those on temporary visas.

In Figure 3, we see that from this same database the picture has changed. Even greater proportions are coming from East and West Asia; there is some increase from Europe but not nearly as much.

FOREIGN STUDENTS IN THE UNITED STATES

By Region of Origin



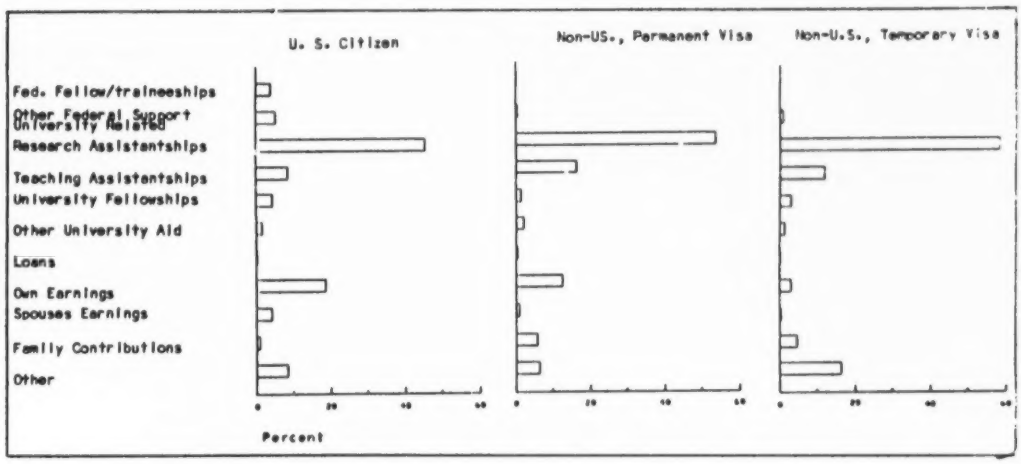
SOURCE: Institute of International Education

Figure 4 shows the primary source of support in graduate school of doctorate recipients, by citizenship, in 1984. Students in the following catagories are represented in the data: U.S., Non-U.S. Permanent Visa, Non-U.S. Temporary Visa.

PRIMARY SOURCE OF SUPPORT IN GRADUATE SCHOOL OF DOCTORATE RECIPIENTS, BY CITIZENSHIP

Engineering Fields

1984

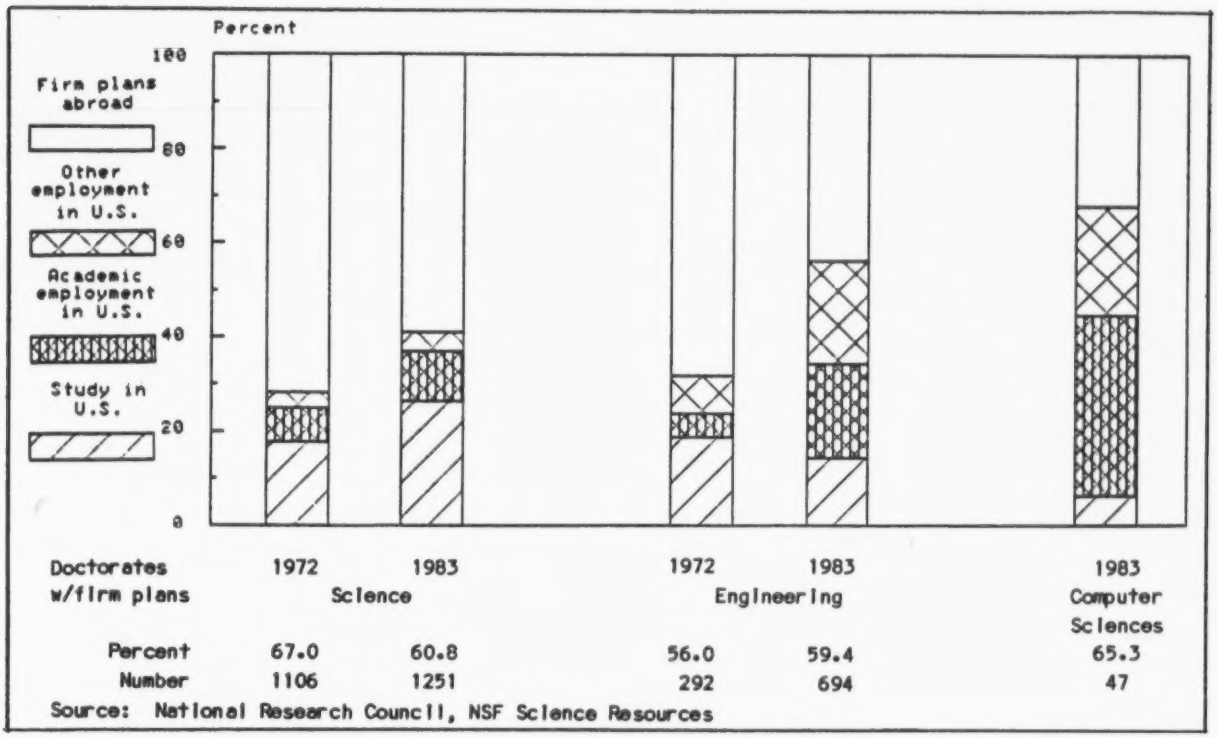


SOURCE: National Research Council and Division of Science Resources Studies/NSF

Across the groups, the primary source of educational financing for those in the sciences was through research and teaching assistantships for high percentages of 20% - 30%. About 40% - 50% of foreign doctoral students receive funding through research assistantships. Research assistantships were cited much more frequently for engineering students in each group represented on the charts.

Figure 5 examines postgraduate plans of foreign doctorate recipients with temporary visas. Two-thirds of the foreign doctorate recipients had firm plans after graduation and increasing numbers of students on temporary visas reported that their plans include staying in the U.S. A larger percentage of graduates in engineering than in the sciences plan to stay, and the majority of students in computer science plan to stay, although the number is small.

POSTGRADUATION PLANS OF FOREIGN DOCTORATE RECIPIENTS WITH TEMPORARY VISAS



Doctorates w/firm plans	1972	1983	1972	1983	1983
	Science		Engineering		Computer Sciences
Percent	67.0	60.8	56.0	59.4	65.3
Number	1106	1251	292	694	47

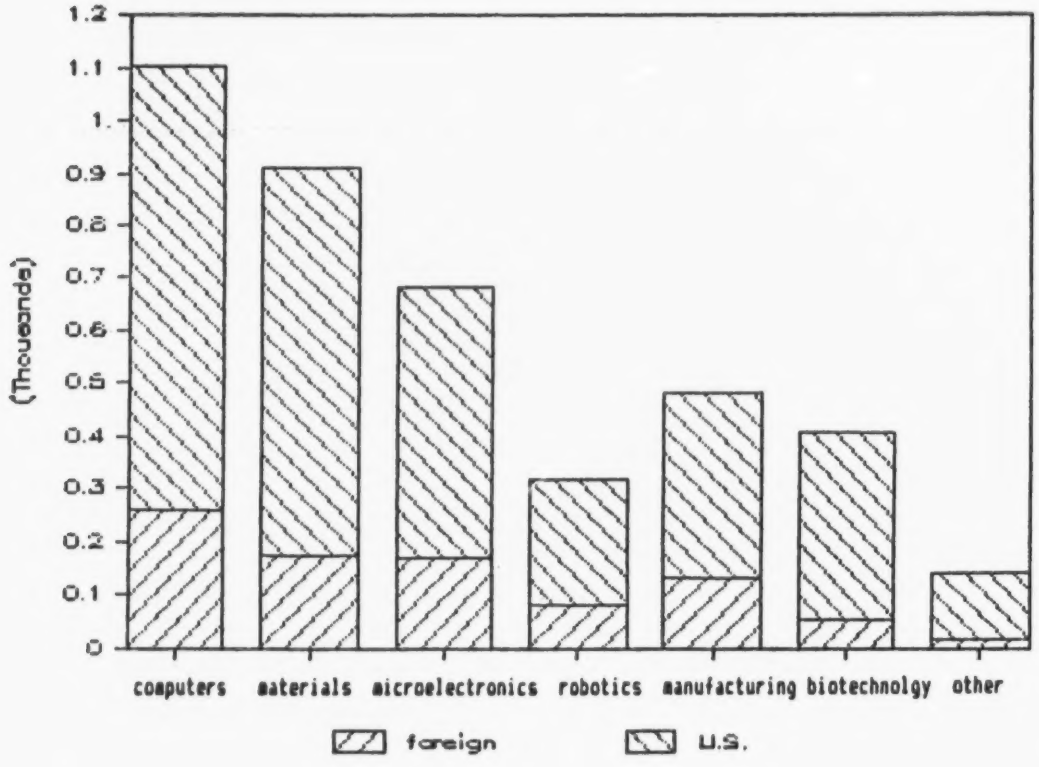
Source: National Research Council, NSF Science Resources

Postdoctoral fellowships are declining, which is one reason for engineering graduates staying in the U.S. Academic employment in these areas is increasing as is employment in business and/or industry.

Important data gaps exist, such as data on faculty in the fields of science and engineering. SRS is planning a survey asking for the U.S./foreign status of faculty to fill this particular gap.

One of the SRS education panel surveys, using the quick response method of obtaining information, has examined whether the faculty were U.S. or foreign trained in terms of their baccalaureate degrees (figure 6). The results revealed that a large proportion of the faculty do have foreign baccalaureates.

ENGINEERING FACULTY IN EMERGING AREAS, BY LOCATION OF BACCALAUREATE TRAINING, 1983



Joel Barries, National Science Foundation

Available and Unavailable Data

The subject of this talk will be the labor force participation of foreign nationals in the U.S. economy. First, the databases will be described. Mike Finn has a grant to analyze the data from a survey of experienced scientists and engineers carried out by SRS under the direction of Michael Crowley. Another survey to be discussed is a follow-up study of doctorate recipients completed by Betty Maxfield of the National Research Council. This is a stock survey of the doctorate recipients in the U.S. at the time they receive their doctorates to determine their plans at this point. Dr. Finn has studied whether these graduates actually go where they had planned.

A survey now in the field - a quick response panel of representives from major industries employing scientists and engineers - is underway to examine U.S. industrial labor needs for foreign nationals. Directed at about 300 employers of scientists and engineers, this survey has studied labor market conditions on an annual basis since 1981. We have identified people within these companies who are knowledgeable about company employment requirements. In some cases, they are directors of personnel, vice presidents of human resources or the heads of college recruiting. These people are able to tell us about employment patterns and how companies utilize foreign nationals. Results of this survey, whose objectives are shown in the accompanying table, will be coming soon.

Some of the questions we want to answer include the following. Are there differentials between industries? Why do various industries hire foreign nationals? Are they the best who come through the door or are they hired because of the lack of U.S. graduates? The pretests show that on the average foreign nationals run between three and five percent of the scientist and engineer workforce in American industrial firms. The proportion made up of scientists and engineers from abroad who have become naturalized citizens is much higher. In areas such as Silicon Valley, the numbers are much higher. At major electronic firms, the numbers of foreign nationals may be as high as one-third and some businesses said they would have to shut down if they could not get these people.

One way to obtain more laborers is to allow more immigrants with experience to enter. In 1981, there were severe shortages in computer science and electronics. The recession of 1981-82 could account for the moderation of these numbers. In 1983, only about ten percent of employers in any field said they had shortages. However, the results of the fall of 1984 survey reveal that shortages may be increasing again so the situation could be worse in 1985. This survey is summarized on page nine of the May 1985 issue of Manpower Comments, the Scientific Manpower Commission's periodical.

The problem with obtaining information from separate surveys includes differential response rates which prevent cross-tabulating the data. There are serious gaps in the data, requiring adjustments, and additional information is needed. However, one is able to piece together a fairly accurate picture of the utilization of foreign nationals, including immigrants, and what they contribute to our labor force. Most of the preliminary data may be found in Participation of Foreign Citizens in U.S. Science and Engineering.

There are restrictions on the U.S. hiring of foreign students and graduates. The defense industries cannot hire them for security reasons; Department of Commerce regulations emphasize the caution that industries must take to reduce the chances of unauthorized technology transfer. These restrictions, as well as pending legislation, will further restrict companies in employing scientists and engineers from overseas.

EMPLOYMENT OF FOREIGN NATIONAL SCIENTISTS AND ENGINEERS (S & E) IN U.S. INDUSTRY

Survey Objectives

I. Employment patterns for foreign national S&E's in U.S. industry
   - A. Proportion in all S&E fields
   - B. Employment differences according to types of industries and geographic location
   - C. Career patterns
   - D. Employment in technical (non-professional) positions

II. Hiring patterns for foreign national S&E's in last 12 months
   - A. Employer reasons for hiring foreign nationals
   - B. S&E fields and subfields of new hires
   - C. Employment of experienced vs new graduate S&E's
   - D. Recruitment for experienced new hires in U.S. or abroad
   - E. Educational level of new hires

III. Sponsorship of foreign national S&E's
   - A. Extent of sponsorship among companies
   - B. Reasons for sponsoring/not sponsoring
   - C. Costs involved in sponsoring

IV. Future plans for hiring foreign national S&E's
   - A. Changes in next 12 months
   - B. Effect of more flexible immigration laws on hiring practices

Michael Finn, Oak Ridge Associated Universities

U.S. Utilization of Foreign Scientists and Engineers

Some of the results of a recently completed study on Foreign National Scientists and Engineers will be discussed.

Others can provide data on the number of degrees granted to foreign nationals by U.S. universities. I made estimates of the proportion of these foreign national graduates who stay to work in the U.S. This information is difficult to obtain from follow-up studies because such studies are usually plagued with a higher non-response rate for foreign graduates and biased statistics usually result. With the help of people from the National Research Council and the Social Security Administration, another method was developed, at least with the Ph.D.s. People who received their Ph.D.s in 1980 or 1981 were asked not only to report their plans, but also to report their social security numbers on the Survey of Earned Doctorates. These were sent to the SSA which calculated the proportion having more than $5000 in earnings in 1982. These numbers were then compared with those for U.S. citizens receiving their Ph.D.s in 1980 or 1981. Results, shown in Table 1, indicate that 62% of non-citizen graduates, and half of those on temporary visas in engineering and computer science remained in the U.S.

Table 1

Ph.D.'s: % Working in U.S., 1980-81 Graduates in 1982

Field	Temporary Visas	Temporary & Permanent Visas
Eng. & Computer Sci.	50	62
Phys. Sci. & Math.	42	56
Life Sciences	26	40
Social Sciences (Including Psych.)	19	40

Source: ORAU based on special tabulation from the Social Security Administration

Separate estimates are given in Table 1 for two different definitions of foreign nationals, because in practice there are two different definitions used by those who collect and publish statistics on degree awards. The Engineering Manpower Commission and the NCES do not include persons with permanent visas in their definition of foreign nationals. So the estimates in the first column of Table 1 are most appropriate to use with their degree award data. However, the data on doctorate degree awards collected by NRC do include foreign nationals with permanent visas at the time of graduation, and the second column of Table 1 is the appropriate one to use with this broader definition of foreign nationals.

We note that the data from NRC show that in recent years about 50% of doctoral degree awards in engineering have gone to foreign nationals. Table 1 says that 62% of these stayed to work in the U.S. This means that, in engineering, foreign nationals make up about 36% of the new entrants to the workforce with doctorate degrees from U.S. universities.

The estimated one year in-flow of foreign nationals in science & engineering to the U.S. labor market in 1981 is shown in Table 2. These data include people entering the U.S. labor force before having attained immigrant status. The INS defines immigrant status as coming with the change from a temporary to a permanent visa.

TABLE 2. ESTIMATED 1 YEAR IN-FLOW OF FOREIGN NATIONAL SCIENTISTS AND ENGINEERS TO THE UNITED STATES LABOR MARKET, 1981

Employment Field	No. U.S. Degree	Degree from a U.S. University	Total
Engineers	1,990	7,656	9,646
Ph.D. Engineers	209	765	974
B.S./M.S. Engineers	1,781	6,891	8,672
Scientists	1,338	6,108	7,446
Ph.D. Scientists	302	1,125	1,427
B.S./M.S. Scientists	1,036	4,983	6,019

Note: These estimates exclude persons working outside science and engineering in 1982. Estimates of foreign national graduates of U.S. universities entering the U.S. workforce which do not make this exclusion are 12-14 percent higher.

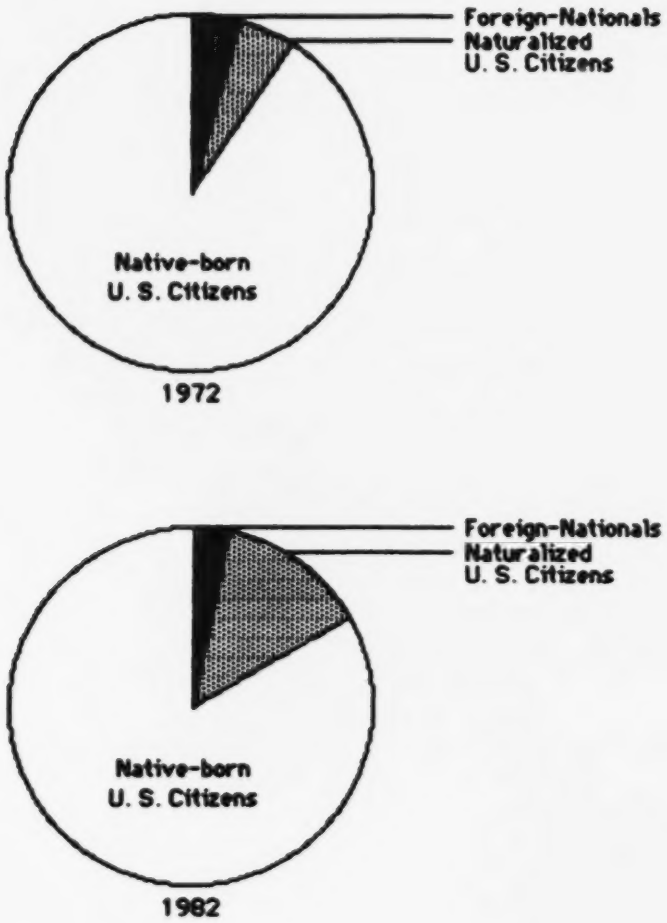
It appears that 90% of the in-flow is not made up of Ph.D.s. In fact, a substantial proportion of the increase in the last decade has been made up of master's level people in science and engineering.

The NSF did a survey in 1982 and I compared the results with a similar one conducted in 1972. As shown in Figure 1, the proportion of immigrants has really increased. And it is the proportion of naturalized citizens that has been increasing. The proportion of foreign national scientists and engineers in the U.S. workforce did not increase because of the tendency of immigrants to become naturalized citizens at a rapid rate.

As shown in Figure 2, foreign nationals have higher degrees than either U.S. natives or naturalized citizens. In the 1970's there was a big increase in master's level immigrants, with that group increasing at a faster rate than the Ph.D. level immigrants in the workforce.

Figure 1

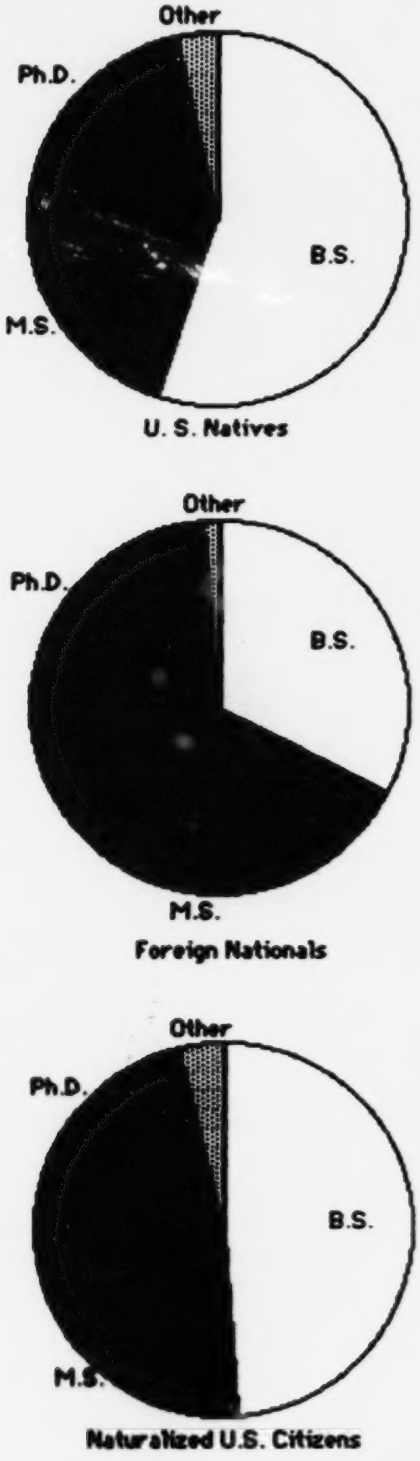
Immigrants as a Percent of the S/E Workforce,
1972 - 1982



Source: ORAU, based on Postcensal Surveys, 1972 and 1982

Note: The dates of the surveys are 1972 and 1982, but each survey includes only persons who were in an S/E occupation in the decennial census year (1970, 1980)

Figure 2
Educational Attainment of S/E's, by Immigrant Status, 1982



Source: ORAU, based on 1982 Postcensal survey

Figure 3
Immigrant S/E's by Type of Employer, 1982

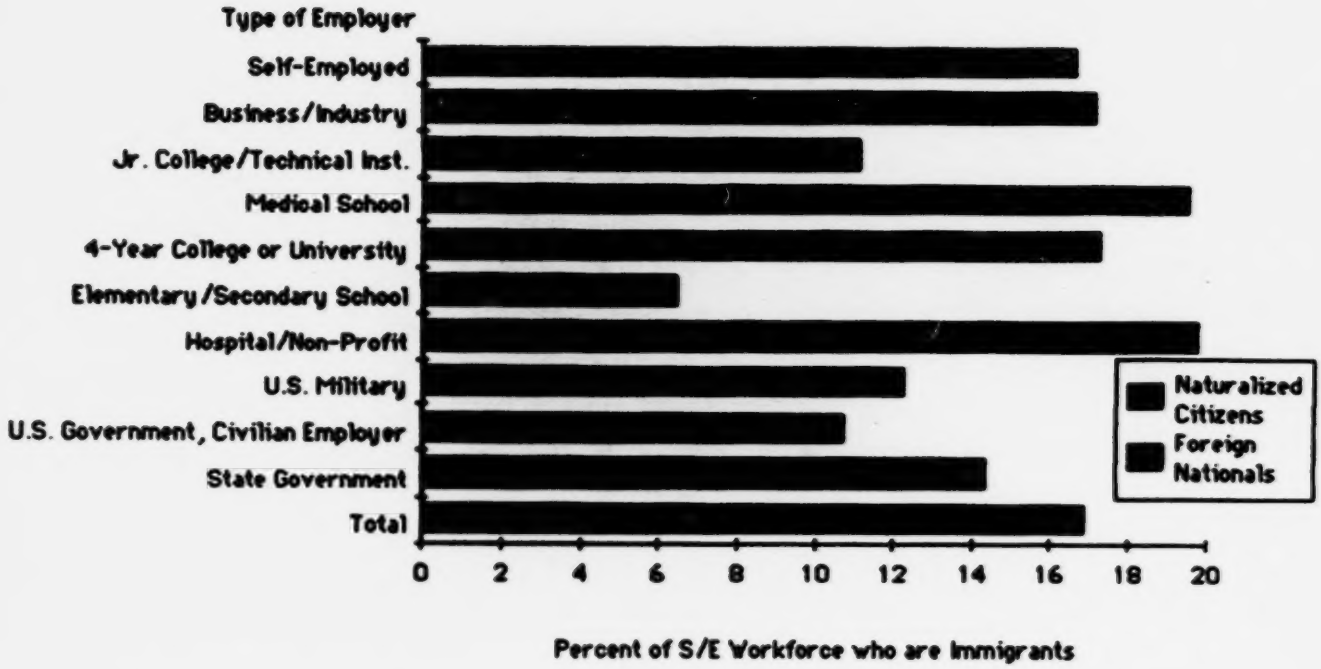
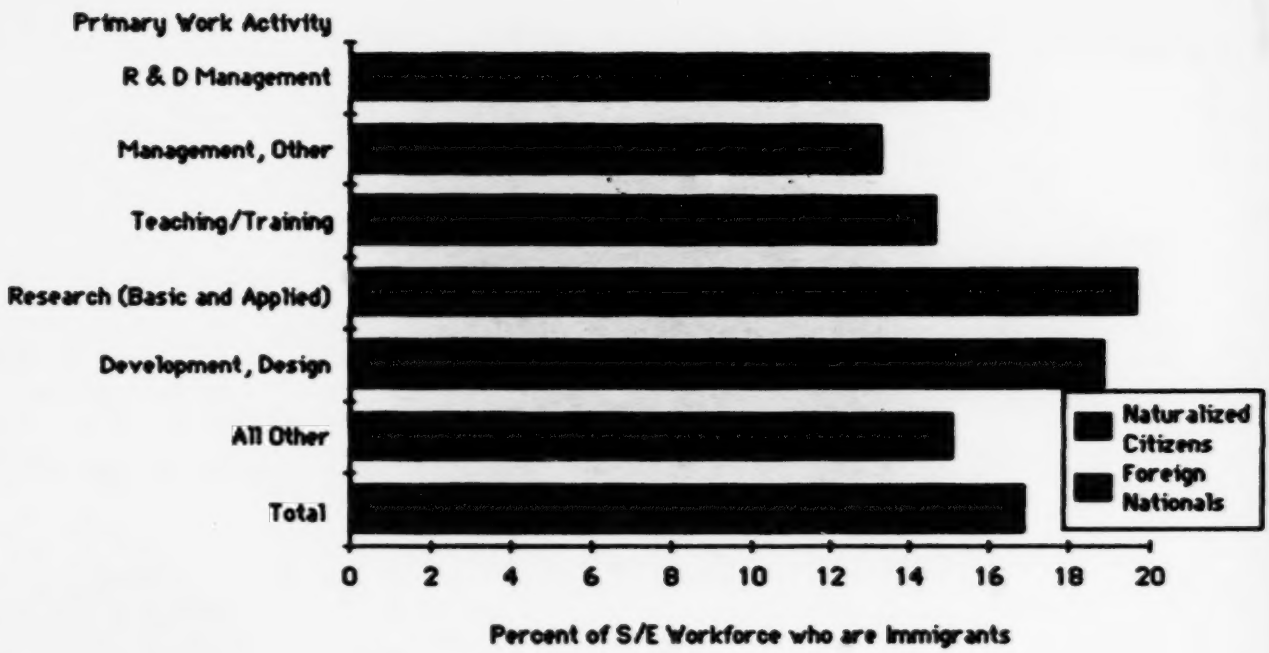
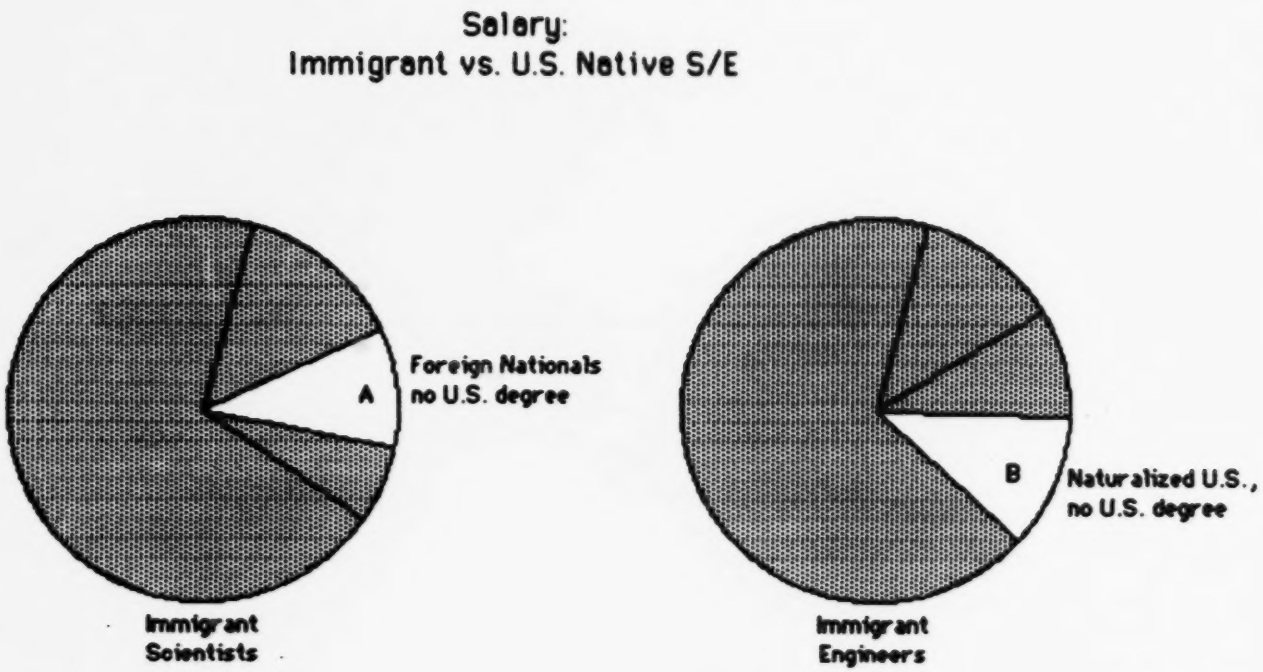


Figure 4
Immigrant S/E's by Primary Work Activity, 1982



Source: ORAU, based on 1982 Postcensal survey

Figure 5



Finn.Salary.ABC

Immigrants are involved in all kinds of work but they tend to be concentrated in research, development and design more than in other activities. In contrast, among the scientists and engineers reporting teaching or non-R&D management as their primary work activity foreign nationals are less frequent than they are in the work force as a whole. At least for teaching this is somewhat surprising because so many of the foreign nationals have advanced degrees. (Figures 3 and 4)

A report on occupational data on scientists and engineers will be available from NSF in June and can be received on request.

Do foreign nationals earn as much as U.S. citizens in science and engineering? No, they earn approximately 2% to 5% less as shown in Figure 5. They tend to be younger than their U.S. counterparts and their wages increase about 3% per year of work experience, so the small salary discrepancy can be readily explained in terms of less work experience.

In addition to comparison of average earnings, we examined earnings differences using regression analysis with controls for degree level, degree fields, region of residence and other relevant variables, In this manner we tested the hypothesis that immigrants might be paid significantly less than U.S. natives in science and engineering. The results can be summarized as follows. For engineers, foreign national status is not associated with higher or lower earnings. However, there is a premium paid to foreign national scientists who were educated abroad. Those educated abroad earn about 8% more than comparable U.S. native scientists. This may be because those who were recruited from abroad have been "creamed" from the total pool available and earn premium salaries because they have exceptional skills. We found one small group of immigrants who earn less than comparable U.S. natives. This was the subgroup of immigrant engineers who have become naturalized citizens but who earned no degrees from U.S. universities. This group earns about 2% to 3% less than comparable U.S. natives, but is not very representative of all immigrant engineers because it is a small component of the total. On the whole there is virtually no evidence in our representative sample of over 13,000 observations for the hypothesis that foreign born engineers earn less than U.S. native engineers, especially for the majority who are educated in U.S. universities.

Bill Aldridge, National Science Teachers Association

Costs of Educating Foreign Students

There is a major data gap in information regarding U.S. support for foreign students. In the early 1960s and the 1970s, when half the NSF budget was for education, the U.S. produced lots of scientists and engineers. Now that NSF is no longer providing this level of support, scientists and engineers are being brought in and trained for industrial and academic careers. To what extent are we preparing to educate foreign nationals at the expense of U.S. students? How much research money is going to foreign nationals?

Fifty-six million dollars was cut from the NSF education budget this year, which could have gone to the support of U.S. students. We have the full capabilities to produce U.S. scientists to compete with the foreign nationals whose education is being subsidized by the U.S. government.

How much research money from NIH, DoD, NSF, and DOE is going to foreign nationals who are research assistants, while U.S. students are losing support? How much of the funding at universities - much of which is provided by states - is going to foreign nationals? These are concerns which require data and which must not be systematically avoided.

Concern for science education at the pre-college level has been stated as a documented crisis and yet there is very little being done to address the problems. There is little support from the scientific community and there are even active efforts within the scientific community to prevent solutions to these problems.

We should be worried about educating and hiring our own resource, U.S. citizens, whose numbers in science and engineering are being systematically diminished.

Discussion

Are foreign students more successful than U.S. students in completing S/E degrees? The difficulty of obtaining an accurate count was discussed and it was suggested that looking at the Engineering Manpower Commission's data on enrollment and degrees awarded for the same year and breaking out foreign nationals for both may best supply this information.

Gil Brown, University of Lowell

Is there a bias based upon whether foreign students attend public or private colleges or universities? No, not private as opposed to public but there certainly is a bias between doctorate and non-doctorate granting institutions. Only a small number of engineering graduates come from private schools.

Dave Reyes-Guerra, Engineering Manpower Commission

The Engineering Manpower Commission does not have a standard way of dealing with statistics in the field of computer sciences. These degrees may be lumped with mathematics or engineering and this can diminish their significance. The field is still going through metamorphosis, but the separate professions have to be recognized.

Panel Discussion on Policies - Alan Fechter, National Research Council, Moderator

Mary Gray - American University
Admissions Policies and Effects in Computer Science

Jack Doyle - Institute of Electrical/Electronic Engineers
Laws Governing Utilization of Alien Engineers in the United States

Bud Green - General Electric
Problems in Industrial Utilization of Foreign Engineers

Lucius Walker - Howard University
Limiting Foreign Enrollments is Not the Answer

Gwen Robosson - Fragomen, DelRey and Bernsen
Obtaining Clearance for Foreign Graduates in Industry

Michael Nacht - University of Maryland
The East Asian Edge, Decay Prevention, and Synergism

J. Chester McKee - National Research Council
When Visiting Scholars Don't Want to go Home

Mary Gray, American University

Admissions Policies and Effects in Computer Science

As chair of the Math/Computer Science Department at American University, I have noted problems arising from admissions policies being removed from departmental control. In particular, a reliance on foreign governments results in an overrepresentation of males and, also, a lack of diversity in economic backgrounds.

Another problem comes with the limited employment opportunities for foreign students. There are few jobs for them offering needed practical training. I would like to see more international students working at jobs in elementary and secondary schools on a co-op basis.

There is often difficulty filling positions. For instance, no U.S. citizen applied for the last job I advertised. Thus, it may be necessary to relax standards in order to fill the jobs.

Jack Doyle, Institute of Electrical/Electronic Engineers

Laws Governing Utilization of Alien Engineers in the United States

When the alien student completes school, if he wishes to work in the United States it is difficult because there are immigration quotas. The hooker, if I can so call it, is a category in the immigrant quota known as the Third Preference. It only amounts to about 10% of the immigration quotas but it is made up of - and I'll quote from the statistics on it - "members of the profession or those who because of their special ability in the sciences and arts will substantially benefit the welfare of the United States and who are sought by an employer in the United States." It is this shortcut that most temporary visa aliens use to get their green cards or their permanent visas.

However, the law says a couple of things must be proved. One is that qualified United States workers are not available; two is that the alien prospective employee will be paid the prevailing wage for the job he or she will do. This means a lengthy process by the Department of Labor involving advertising the job. It is handled by the state employment services, often not very well.

Many examples have come to the surface where the prevailing wage requirement has been badly overlooked. Processes such as the following seem to occur. An alien the employer wishes to hire is offered a very low salary relative to his educational background. He is likely to accept because his alternative, if he is through school, is to return home. An ad is placed but the employer finds no United States citizen interested in the job because of the low salary. If the state employment service is not careful to judge the reasonableness of the salary, the alien not only gets the job but, more important to him, he gets quick status as an immigrant. Close watchers see these ads all the time. They come through state employment agencies; they don't reveal the employer. The key is to look for salaries below $17,000 for a Ph. D. with 6 months of postdoctoral training, $19,000 for a B.S. in computer science, $20,000 for a Ph. D. in mechanical engineering, $20,800 for a M.S. in electrical engineering. All of these are out of actual ads placed in an attempt to get an immigrant hired.

It is difficult to accept that any job at the bachelor's level is of a nature that no United States citizen could be found to do at the proper price, when we graduate some 70,000 plus engineers every year. Conceivably, when one moves to the doctorate level.

there may be some people with exceptional abilities among the immigrants who could prove that they are valuable and should be used. But if they are unique, they should be worth more than the $20,000 a year they are getting paid. It appears that two out of three aliens go on for a master's or doctoral degree versus only one out of five U.S. graduates. It also appears that one of the reasons U.S. graduates don't go on is that the salary levels for doctorates are really not commensurate with the work required to get a doctorate. We have to consider whether the presence of the alien engineers in this workforce of doctorates is not depressing that salary level.

There have been proposed immigration laws in congress recommending sending students back to their countries after graduation for two years before they can enter the immigration process. I think that law is going to come back again and have another shot. It did not pass the first time. The IEEE generally supported it but with an exception for students of exceptional ability, demonstrated by a significantly higher salary offer. In my mind, such a "return law" would not harm U.S. industry in any way if it included the exception. It might even help in that it would send home the average student, who cannot qualify under the exception, and might get the salary levels raised so that more United States students would be interested in going on for doctorates.

Bud Green, General Electric

Problems in Industrial Utilization of Foreign Engineers

I'm a lawyer with G.E.'s Research and Development Center. The mission of our organization is to provide the technical leadership necessary to hold or better G.E.'s competitive position worldwide in an environment in which the U.S. competitive position is slipping fast. Most of you have heard of the findings of the President's Commission on Industrial Competitiveness. Accelerated R&D has been prescribed and the system will be hard-pressed to provide it.

To fulfill this need, we are betting heavily on the university connection. Industry and government are both looking to universities to provide more basic research and more technical talent to fill our research jobs. Over the past several years, there has been a dramatic increase in university/industry collaborations. Of the more than 150 such programs turned up by Cornell's recent study, about two-thirds were formed in the last five years alone. The government - the National Science Foundation - has been fostering these collaborations. Just last month they announced that $95 million will be spent over the next five years to establish six university research centers. The government agencies have been encouraging and fostering university involvement in their own programs. The Department of Defense urged all its major contractors to give the universities fuller exposure to the industrial environment in an attempt to close the gap between data acquisition and application. Major initiatives, including Star Wars, the DOD's strategic computing initiative, the U.S. Air Force artificial intelligence in manufacturing and other new aeronautical and space programs, all focus on heavy university involvement.

It's a good game plan but what's the problem? The problem stems from the fact that nearly 42% of the graduate students enrolled in the engineering schools are foreign citizens and, of course, the majority of these are on temporary visas. The problem is that our export control regulations prevent industry from interacting with the temporary visa holders, exposing them to the environment of industry, if you will, and our immigration laws prevent our hiring them.

It is perhaps not generally appreciated that the export of technical information is controlled by our export control laws and the release or disclosure in the United States to a foreign citizen on a temporary visa is an exportation. To determine if we can disclose

a specific piece of information to a temporary visa holder, we examine two separate regulations, the International Traffic in Arms Regulations, administered by the Department of State, and the Export Administration Regulations, administered by the Commerce Department. These regulations are exceedingly complex. They generally require us to obtain a specific license from the Department of State to disclose to any temporary visa holder unpublished technical information concerning an item designed for military use, and from the Department of Commerce to disclose technical information applicable to civil aeronautical and space applications.

Therefore, we must apply for and obtain a separate export license to cover each proposed interaction between our technical staff and a university researcher who has a temporary visa, concerning research in many technical areas. The effort and delay involved in obtaining a separate license to cover each proposed interaction is formidable and can greatly inhibit university-industry collaboration.

Last December, a new provision appeared in the State Department regulations that specifically exempts from the requirement for a license, "disclosure of technical data in the U.S. by U.S. institutions of higher learning to foreign persons who are their bona fide and full-time regular employees." This exemption would apply if the employee is not a national of a "bloc" country and is informed in writing that he or she may not transfer controlled technical data to other foreign persons. It does not apply to full-time employees of industrial research organizations, however, nor does it allow industrial research organizations to disclose controlled technical data to university employees covered by the exemption. The net effect of these rules is to encourage the use of foreign researchers on university teams but to inhibit close collaboration between industry and the university research teams who use them.

We believe that the State Department's approach in exempting foreign persons employed full time by a university in the U.S. is sound and constructive. We feel that this exemption should be expanded, however, to cover researchers employed by industry as well as university employees. It should also be enlarged to include direct disclosures between university and industrial researchers rather than only between the researcher and his or her employer.

The Commerce Department regulations do not have even an exemption with respect to the technical information it controls that corresponds to the existing State Department exemption. We would urge the Commerce Department to adopt an exemption comparable to that we are suggesting for the State Department regulations. These simple changes would go a long way toward clarifying a very confused and complex situation.

Finally, as to the immigration matters, our experience is a little different from what Jack Doyle of IEEE indicates. We find it extremely difficult to get through the process to hire a foreign national. I think Gwen Robosson can tell us more about that later.

Lucius Walker, Howard University

Limiting Foreign Enrollments is Not the Answer

I'll know never to follow Jack and Bud Green: it seems they've covered the essence of what I have to say. We're facing two of kinds of problems. One is our long-term wish that somehow young men and women in the United States, particularly black Americans and females, be placed in the position to take advantage of the scientific and engineering opportunities which this nation offers. The second problem is that human capital development is a long-term proposition and requires foresight and diligent investment over

a long period of time in order to realize goals. If we were to start today with a major investment in developing young people, at best we would see significant representation at the Ph.D. level by the year 2000.

In the meantime, technology changes very rapidly and we're pressed to keep up with the rate of change. This puts us in a position of having to exploit the best talent which is available to us. We also must consider the international goodwill that derives from our providing educational opportunities for people throughout the world. There are two other things I want to comment on.

One is the Simpson-Mazzoli bill, already noted, which was tabled last year. I understand that the legislation is not to be brought before the congress in the current year. It involved a requirement that foreign graduates return home for two years. The second critical area is the so-called export control act, which requires licensing for the export of products and technical data. The concept of technical data is one that I think rightfully concerns industries and institutions of higher education. I'll just expand by reading a statement from this act which Bud Green mentioned. "The technical data may be tangible or intangible and includes knowledge and software. It may be exported by actual shipment or transmission out of the United States or by release orally or visually to foreign nationals in the United States. All exports of technical data must be made under validated export license unless specifically permitted under one of the two technical data general licenses."

I'm not an expert in this area, but conceptually it poses a critical compliance problem, not only for industry but for engineering schools which are heavily engaged in work in solid state electronics, computers, VLSI and other areas where the shortage of U.S. talent has made the use of international talent critical to remaining on the leading edge.

I might tell a little story in closing. Not long ago, one of my collegues from another institution, who is certainly sympathetic to the idea of more Americans being involved in our workforce in critical areas, wrote a letter asking what we are doing at our institution to reduce the number of foreign graduate students. I wrote back indicating that, first, the critical questions were what are we doing to increase the enrollment of American graduate students, and, second, if there is no marginal cost, we should continue to enroll foreign students. If we are to keep our programs at the frontiers of technology, then we have little choice but to take advantage of the talent currently available.

Gwen Robosson, Fragomen, DelRey and Bernsen

Obtaining Clearance for Foreign Graduates in Industry

I want to address briefly the process that an employer has to go through in order to hire a foreign national on a full-time permanent basis. You heard a little bit about the labor certification process. Our experience is that this is a very difficult endeavor for any employer to undertake. To begin with, the employer has to establish that there are no qualified U.S. workers to fill a given position. In order to do that, a recruitment campaign has to be undertaken. That involves advertising for the position in the New York Times or a newspaper of general circulation, posting a notice of job opportunities on the business premises and then submitting the application to the local office of the Department of Labor with the results of any recruitment. This process in the New York region, for example, is taking about eight months to complete. It's very lengthy; there's a lot of correspondence that goes back and forth with the Department of Labor.

For physicians, or for foreign nationals who hold advanced degrees in the natural sciences, computer science, mathematics and in engineering, one proposed change in the

process for immigration would be to include such foreign nationals on schedule A, Group 1, of the Department of Labor regulations, which are occupations that are pre-certified as being in short supply in the United States. Then, for example, if an employer wished to hire a foreign national who held an advanced degree in engineering, he could, rather than going through the labor certification process, submit a petition directly to the Immigration Service on the basis that such individuals are in short supply in the U.S. This would cut down significantly on the immigration process and ease the requirements for employers.

The proposal in the Simpson-Mazzoli bill that all foreign nationals who are attending school in the United States return to their home country for two years, would create serious problems for employers. If these students were forced to return home, it would be difficult to maintain the continuity and bring them back after two years. The current sentiment seems to be that such provisions would not be included in the Simpson-Mazzoli bill if, indeed, it does achieve final passage.

Michael Nacht, University of Maryland

The East Asian Edge, Decay Prevention, and Synergism

I'm a faculty member of the School of Public Affairs of the University of Maryland. My comments will be drawn on four experiences I've had. One is a study I completed with Crawford Goodwin, Dean of the Graduate School at Duke, sponsored by Elinor Barber, on how colleges and universities in this country make decisions concerning foreign student enrollment. The title of that study is "Absence of Decision." The second experience upon which I would like to touch briefly is the perspectives of the foreign students themselves when they return home, what they think of the experience they have had. We did a case study in Brazil a couple of summers ago titled "Fondness and Frustration." A third study in progress doesn't yet have a silly title. The fourth experience is one I've had at the University of Maryland chairing an International Education Task Force for the Behavioral and Social Sciences Division of this very large university.

There are several topics I'm not going to discuss in depth. The first concerns faculty and administrators. For those who are involved in decision-making in universities, the essential problem with respect to our topic today is that there is a fundamental tension between the power of individual senior faculty in departments, on the one hand, who largely make ad hoc decisions concerning individuals from abroad with whom they would like to associate in their departments in science and engineering, and the goals and strategies that frustrated administrators might like to adopt for their institutions. If you're looking for some great coherence on the part of the major academic institutions with respect to an institutional strategy for foreign students in engineering and science, you don't find it. The reason is this inherent difficulty between administrators, who may have a somewhat broader perspective, and individual and powerful faculty members and departments. I think a generalization which largely holds is that the higher quality the institution, the more decentralized the decisionmaking. Therefore, it's very difficult for an assistant dean who's concerned with international education to tell Paul Samuelson in Economics that he ought to admit seven new Taiwanese to study economics. That's somewhat of an absurd example to make the point.

That's the first subject I won't talk about. A second one I won't talk about concerns the absence of Americans in graduate engineering education which is leading to a lost generation of American educators in engineering schools in the United States. While the better universities are doing fine, the second, third, fourth and fifth tier engineering schools with major investments in capital equipment and so forth really have to use what we call foreign students as filler. They must admit foreign students for, if they don't, all

of their investments in their engineering departments will go down the drain. They will have to close down.

A third subject warranting discussion, but not this morning, is the many side payments to international education, not normally appreciated unless looked at in some detail. These include faculty research projects held with people from abroad, consulting arrangements for faculty and for students, internships for students, foreign investments made by successful graduate students who go home and have fond memories of Ohio State or Cal Tech or Stanford or whatever and re-invest in the United States. One of the major problems, however, comes when Johnny is not admitted because Mr. Kim has a better GRE score and this leads to all kinds of additional problems. I have many fine examples of this, not to be addressed this morning.

In the remaining time, I would like to mention three points. The first is what I call the East Asian edge, a phrase borrowed from the title of a very good book. There is no doubt that the tremendous growth in international education in science and engineering is from East Asia: from Japan, from Korea, from Taiwan, from Malaysia, and it's increasingly from the People's Republic of China. It is also from India and Pakistan. To give you one startling statistic, there are 50% more Taiwanese studying in this country than the combined number of students from all the countries of Europe.

There are two major issues associated with East Asians studying in this country. One, as finely pointed out by the gentleman from G.E., has to do with economic competitiveness and economic protectionism and the second has to do with national security policy. There are intimate connections here and they are difficult to sort out. I'll give you one example. A dean from a prestigious engineering school on the West Coast was talking about the large numbers of people from the People's Republic of China who had been admitted to their electrical engineering department. He said that within 24 hours the school received two urgent telephone calls. One was from the Department of State saying it was wonderful, fantastic, keep up the good work. Right after that, the Defense Department called and said that if you admit any more of these characters, we're going to close you down, we're going to stop your defense contracts. This was in the early period when the Reagan administration was still trying to sort out its policies toward the People's Republic of China. There are enormous implications when you admit people from countries which are both potential adversaries and potential allies, both economic competitors and economic partners.

Sometimes we have to just about get hit in the head with some of the aspects of this problem before we understand them. For example, in the area of nuclear weapons proliferation, the race that's going on now in the subcontinent between India and Pakistan is going to make international headlines very shortly if you haven't noticed them already. And if it is learned that key people in the Indian and Pakistani nuclear weapons programs were trained at MIT and Cal Tech, you can be sure that's going to trigger some telephone calls. Thus, there are enormous implications for those of you who are in the science and engineering manpower field in terms of the impact of having these non-Americans studying here that far transcends how many Ph. D.'s there are or how many people get jobs in Silicon Valley.

A second point to mention is what we call decay prevention. It's a problem for all of us. International students have a particularly hard time because they are often trained in very sophisticated and esoteric techniques. Then they go home and they don't have the infrastructure to maintain their skills. This is, in fact, the subject of our third major study. Either their education was a poor fit - such as the Stanford graduate who studied satellite stability, then went back to Brazil and is now digging roads in the Amazon - or

they just don't have the contacts to keep up their skills. How should foreign students keep up their skills when they return home? By the way, the vast majority of East Asians who come to this country do go home. They don't stay here and, frankly, they're not particularly interested in becoming American citizens, contrary to what you heard this morning. It is a big issue and it is one that American institutions of higher education contribute to. There is very little contact between American colleges and universities and their alums once the alums disappear into the Amazon. We just assume they will do fine. But they don't do fine; they need to be nurtured. And there are lots of extension programs and other kinds of things that can be done.

The third area, following up again on the General Electric perspective, is that it's very vital to promote the synergism of government, academia and business in these areas. If you look at the high growth areas in this country - Silicon Valley, the Research Triangle in North Carolina, Route 128 in Boston, Austin, Texas - it's that synergism. Slowly, but surely, government, business and academic institutions are cooperating and the net effect is greater than what any of those sectors could do alone. There's very little of this in the developing world. Yet it needs to be nurtured and it can be nurtured with the help of American institutions in a way so as to benefit them and to benefit us.

J. Chester McKee, National Research Council

When Visiting Scholars Don't Want to Go Home

My comments are based on an operational program that we in the Office of Scientific and Engineering Personnel of the National Research Council have been involved in for thirty years. We feel that this program has contributed greatly to the development of scholars throughout this country and foreign lands. In this program, the NRC receives applications, convenes panels, conducts reviews, then selects on the basis of ability and quality, recipients who receive awards to become guest investigators in a federal laboratory. They make a research proposal as a part of the application and this proposal is one of the items reviewed by the panelists. In short, we have on tenure, at any one time, approximately 85-90 - last year we had 91 awards - to non-U.S. nationals. This represents about 25% currently of our total postdoctorates on tenure. These non-U.S. nationals are both new doctoral recipients, that is people who have received the degree in recent years, and seniors who are faculty members at institutions in other lands.

Our problems in dealing with the policies stem from the operational side rather than the planning you have been discussing today. We have five main areas with which we have to deal on an every day basis. These are travel arrangements, including visas, acceptability to the laboratory - call it security if you will - the issue of taxes worked out between our Internal Revenue Service and visitors in this country, and lastly, and probably most importantly, the issue of our role in the determination of waivers on the two year home rule, which is in effect for people who hold the J-1 visa and occupy guest slots as visiting scientists or engineers in this country. On the last issue, I would simply say that this is one that causes us a great deal of frustration. And it seem to be one that has caused frustration for others here today.

How does the mechanism work to make the determination that a person should stay after being here on a visiting scientist visa? Currently, we receive from the Immigration and Naturalization Service a document that asks us, the sponsor of this visiting scientist, to affirm that we believe this person should stay in the country. We have very little basis for making this determination. Historically, the way we treat it is to decline generally to ask for a waiver. We feel that is in the purview of the agency, the institution, the industry which the person in question could help. I hope that some attention is given to this matter because it is an issue that needs some real clarification and a better understanding on the part of the sponsors.

Discussion

Bill Aldridge, National Science Teachers Association

I heard comments several times on the dire need for these highly trained people and I would like to point out that our organization, (National Science Teachers Association) and other sources of information, are routinely telling high school students that there are no jobs in science or engineering and that there is very little room in the engineering schools. Students are being discouraged from entering those fields at the present time and that discouragement is extensive.

The evidence we have indicates that there are no critical openings, except in certain subfields of engineering and certainly not in the sciences, at this particular time. And U.S. students are discouraged from entering those fields. In engineering schools, we're told that you can't get into the classes because they are filled.

Bernard Charles, Carnegie Corporation

Just briefly, in talking about the education of foreign nationals, it would be useful to have some foreign nationals on the panel here to talk about their perspective. I also would like to mention that other countries educate foreign students. It would be good to have a view from their experience too. Otherwise, there is a lack of context.

Betty Maxfield, National Research Council

I just came back from a press conference held by an engineering organization and it was said that there are numerous opportunities in the engineering field when it is considered in a broad sense to cover such areas as math and computer science. It was felt that there needs to be encouragement at early school levels for girls and minorities to take the courses which will prepare them for careers in engineering. We do have a problem with engineering education, faculty problems, but work is being done on this.

Lee Grodzins, Massachusetts Institute of Technology

I find it rather strange that students are being discouraged from getting into engineering because the classes are so crowded. That's a very long range point of view and it's certainly different from what we've heard in the past. It seems to me that people are not discussing this whole problem in terms of supply and demand. I think that it should be discussed that way. I'm at MIT where we have a large percentage of foreign students. I think I can say without any question that we discriminate, both overtly and covertly and subtly, against foreign students coming in. For example, the electrical engineering department will not support with its funds any foreign first year graduate students. I think the same thing is true with industries and the industries I know hire foreigners at an overall higher cost because of the expense of the procedures which must be gone through. If you want more Americans, you have to pay them more; if you want more graduate students, you have to give them the kind of NSF fellowships we once had. This is supply and demand. That is what I think is needed.

A.J. Bernstein, General Electric

I'm at the General Electric Research and Development Center. I would like to quote some statistics to you. Notwithstanding that G.E. is undoubtably one of the most attractive employers of scientists and engineers, 40% of the people that we invite in for interviews turn us down because they have more attractive offers. Of the students we do make offers to, only one-half accept.

Alan Fechter - Moderator, National Research Council

I would like to sum up the issues we have covered in this discussion of policies. Here are the things I heard discussed: the question of export controls and the whole question of international competition and international cooperation; security issues; the professional viewpoint that foreign nationals in the workplace depress wages; a possible effect of foreign graduate students on both the gender composition and race/ethnic composition of the graduate student body. I heard discussion and some frustration about the question of the labor certification process. I also heard discussion of the law of return, as it applies to this country. Whether requiring foreign students to return home for two years is good or bad for this country remains to be seen. I heard references to the large number of foreign students leading to a lost generation of U.S. scientists and engineers. I heard about possible problems from threshold effects i.e., where getting above a certain level of foreign students on campus leads to relationship problems. I heard discussion of the possibility that increasing numbers of foreign students may result in a displacement of American students. There was discussion of the international political implications of having large numbers of foreign students in our universities. Finally, I heard concern expressed about foreign students who return to their countries properly utilizing the training they have received in the U.S.

Panel Discussion on Issues - Richard Wilcox, U.S. Arms Control and Disarmament Agency, Moderator

John Hamblen - University of Missouri-Rolla
Faculty Shortages in Computer Science

Jack Doyle - Institute of Electrical/Electronic Engineers
Impact of Alien Engineers on Industry and Universities

Jules LaPidus - Council of Graduate Schools
Internalization of Graduate Education

Roberta Hall - Project on the Status and Education of Women, Association of American Colleges
Foreign Faculty and Graduate Students: How do they Affect the Learning Climate for Women?

Maurice Mountain - Consultant
Foreign Students, Technology Transfer and National Security

Robert Morgan - Washington University
Study of Foreign Engineering Students

Richard Wilcox, Moderator, U.S. Arms Control and Disarmament Agency

The issues seem to center around two broad themes. One is the impact of the substantial growth and proportion of foreign graduate students in our universities on the furture scientific and engineering strength of our country. The second general issue, which is not unrelated, is the fairness or appropriateness on distribution of the limited resources, financial and otherwise, available for scientific and engineering education. That also impacts on the future strength of the country in the sense of whether or not all of the best available talent is being cultivated.

John Hamblen, University of Missouri-Rolla

Faculty Shortages in Computer Science

I'm going to be coming at you from three different directions. The first is as a professor of computer science at a fairly small univeristy of 7,000 in a small town of 13,000. Occasionally, our graduate dean gets concerned about the percentage of international students. Every five or ten years, our state legislators get concerned about it and, at that time, we have to give some attention to it.

First of all, I want to say that I agree with practically all the good things said by the first speaker on the benefits from having international students. On the other hand, there are some problems, particularly in a small community such as ours. Several hundred international students stand out in a small population. One of the byproducts of this is that the foreign students become clannish and that isn't good for them or the U.S. students. We have about 25% foreign students in our graduate department; so that tells you about my interest from the standpoint of the university where I'm a professor of computer science.

From another angle, I represent the Association for Computing Machinery on the Scientific Manpower Commission. ACM is the major society for computer science professionals. There is the IEEE computer society for the computer engineers and the Data Processing Management Association for the information systems types. I have been very

much concerned with having computer science first included today with engineering; then with mathematics. The National Science Foundation is responsible for this. For years, they had us in with mathematical sciences. They are beginning to separate a bit now. ACM recently registered its objection by withdrawing from the Conference Board of the Mathematical Sciences and a main reason for doing it was the lack of identity. We didn't feel it was helping our profession to continue being associated with mathematics.

You probably know that the Scientific Manpower Commission publishes Manpower Comments, which prints everything fit to print about manpower and, occasionally, Betty Vetter gets in something extra. For example, in the last (May) issue, there are three tables on pages 8 and 9 with the label "Math/Computer Science." This completely distorts the picture because the situation in computer science is entirely different than mathematics in terms of supply and demand these days. Right below that, I was shocked to read that there will be no shortage of Ph.D.s to fill academic jobs in the short run. We have a tremendous faculty shortage in computer science. Orrin Taulbee, the other ACM representative to the Scientific Manpower Commission, can tell you that there are five to six hundred vacancies right now for Ph.D.s in computer science in universities. And there is probably another shortage of four or five hundred in government and industry. Too generalized statements are misleading. I was really shocked to find that Manpower Comments was quoting a publication of the National Research Council.

I would like to say more about some of the data problems. Now I'm getting at your from my third position. Since 1972, I've published five editions of Computer Manpower: Supply and Demand by States. This was initiated by a paper I did for my former employer, Southern Regional Education Board, for the fifteen Southeastern states. Then I expanded it to a national basis with the help of grants from the National Science Foundation to collect the basic data. The grants have ended and I found that it just doesn't pay to continue on my own. The response rates are too low. There's one of the data problems: universities are tired of filling out questionnaires. Unless you have a sledgehammer hanging over their heads, they're not going to do it.

A bright side to data collection is that the data being collected by the National Center for Education Statistics is getting better. I'm perfectly happy now with the data they are collecting and I've used it in my last publication.

Another problem is too much aggregation of data, both geographically and by discipline. I did the computer manpower study on a state by state basis and state data are available through the National Center for Education Statistics. It doesn't help people in Indiana to know something is such and such nationwide. For example, some states may have a surplus in a field where there is a shortage nationwide, and the state in question needs to know this for planning.

We need an early warning system. Right now, I still don't have data on the production of bachelor's, master's and doctoral degrees for 1982-83. The data always runs a couple of years behind. What we ought to have is data two years in advance. If we knew how many sophomores, juniors and seniors were enrolled in each major, then we could see what's coming down the pipeline instead of waiting until two years after it has already happened.

According to my estimates of need and according to data I get from the National Center for Education Statistics, we're producing about one-half of what we need at the bachelor's level in computer science, information systems, computer engineering and so forth. We're producing about one-fifth of what we need at the master's level and about one-fifth at the Ph. D. level. We know there is a tremendous shortage.

Jack Doyle, Institute of Electrical/Electronic Engineers

Impact of Alien Engineers on Industry and Universities

About two years ago, there was a shortage of eggs in the eastern part of the United States because of a disease going through the henhouses in Delaware and New Jersey. I'm a regular egg eater; I knew there was a shortage of eggs. I didn't know there was a shortage of eggs from going out and counting those eggs, saying I have X million this year and that's a lot less than I had last year. I knew there was a shortage of eggs because the price went from $.69 a dozen to $1.25 practically overnight.

Some people define a shortage as an inability to get something at the price they would like to pay. Maybe there is a shortage of computer people for faculty jobs. But is the problem one of offering $26,000 a year for these jobs? In a free market, if a shortage occurs, the price goes up.

What are the practical effects of the alien engineers we have and the policies we talked about this morning? At the bachelor's degree level, I'm convinced that the presence or absence of these aliens has no practical effect on the United States and its technological capabilities. About 6,000 are graduated annually and 4,000 of those 6,000 go on to graduate work. Thus, there are only about 2,000 seeking and maybe getting jobs. And since some of the 2,000 not going to graduate school may return to their countries, the number entering the U.S. workforce may be considerably less than 2,000. That compares with 66,000 U.S. citizens graduating at the bachelor's level each year. Given such a ratio, I do not see an impact at the bachelor's level with the existence of these alien engineers.

At the doctorate level, it is another story. All of a sudden the percentage of graduates who are aliens escalates to the 50% range. As we know, the United States citizens don't tend to go on to graduate work as the aliens do. The aliens may have to continue in school: that may be their only recourse other than going back home. Our recent IEEE salary survey shows that a graduating Ph. D. was paid on the average about $35,000 a year while his B.S. counterpart who has been working about 3 years is making around $32,000. This is not a picture, if one looks ahead, to lead a person to conclude that he needs to spend the time, the money, the effort to get that doctorate. The doctors do peak out higher in their careers on our survey at about $56,000 versus $47,500 for their B.S. counterparts but that's still not a very big difference. I would venture to say that if we did a 20 year economic study, we would probably find that the present value of dropping out at the bachelor's level is higher than it is to continue on to a doctorate.

A serious question is whether or not the large percentage of aliens in the doctorate graduate pool has not, in one way or another, caused this depressed level of salaries for doctorates, especially in education. With the choice of getting a job or going home, the aliens are more inclined to take a job at a lower salary level than a United States citizen might. It may be that this feeds on itself in that the large pool of aliens has depressed the salary levels for doctorates to the point where what is called the prevailing wage is lower, but it is nevertheless prevailing, making it easier for them to become citizens because they are being paid the prevailing wage.

Our survey shows a large spread of salaries for those with doctorates. The median, I said, was around $35,000 but the upper decile was around $40,000 and the the lower decile around $26,500. When we look at the job function or primary interest, the lowest decile is in the educational establishments. I would find it hard to believe that students gaining their doctorates, those who had done their best, wouldn't be tempted to go after those higher salaries. I haven't seen data as to where the alien graduates go when they leave

school, which ones go to industry and get $40,000, which ones go to the educational establishments and get the $26,500. But I find it hard to believe that this is just a random spread. There must be some relationship between the students' capabilities and what they are offered and take as a salary. For this reason and because it is of benefit for the U.S. to have the exceptional graduates, the IEEE, although it generally favored the two year return rule, said that exceptional graduates who demonstrated that they are outstanding by commanding a high salary should be exempt from the home return rule. And certainly if a graduate is able to attract $40,000, as some doctorates do, you can't call that wage-busting.

One must wonder if the educational establishments are not solving their financial problems by hiring those who are willing to work for less, who may have to work for less in order to stay in the United States. If so, this is detrimental to the educational system, for it is these people who will be running our educational system in the next generation and teaching our broad base of engineering students for their bachelor's in that next generation. One often hears criticism of industry for paying too much and luring the good students away at the bachelor's level. I say the universities are paying too little and pushing these graduates out to industry.

In summary, I believe the impact of the present laws is minimal on the broad technological base of the United States and its industry when you're dealing with the large number of graduates at the bachelor's level. However, at the doctorate level, the current laws do permit universities to hire aliens at a depressed salary level and possibly to hire those of lesser ability. As a second order of fact, this depressed salary level may discourage the better bachelor's graduates from going on to graduate work.

Jules LaPidus, Council of Graduate Schools

Internationalization of Graduate Education

I was asked to speak about larger issues of the internationalization of graduate education. There is certainly nothing new about students going to other countries to study. If you look at the history of scholarship in the world, leaving aside economic and political issues, you find people who wanted to study something desperately going to where their fields were being defined and to where some kind of official certification of competence existed. That may not be true for American engineering but it is certainly true for American science before World War II. The action was not in the United States at that time but in Europe, for the most part in Germany and England but to some extent in France. For American musicians, it was in Italy and France. So I don't think we're seeing anything terribly new. What we're seeing is that a number of countries are developing technologically and scientifically and, particularly in the fields we are discussing today, they have not yet developed the educational system to support that effort.

I think you will find that for many foreign students what international educational exchange means is learning English and coming to the United States; and for many American students what it means is talking English and staying in the U.S. to work in laboratories with foreign students. Now there was a time when the old mythology said that it's good to have foreign students on our campuses because somehow there is a cultural effect - we learn something but we're not quite sure what - and that the presence of foreign students on the campus is very good for us.

Yet this is not a passive process. Simply having foreign students next to American students in a laboratory does not necessarily enhance the cultural life of the American students. Something has to be done to make sure that happens. And, frankly, not enough

is being done. Secondly, very few American students are going overseas to study anything. Figures I've seen would indicate that fewer than 20,000 Americans are overseas for educational purposes and very few of those, I fear, are in science and engineering. That's compared to over 300,000 foreign students in this country .

I want to talk about the internationalization of education, graduate education in particular. In order to do this, we have to define terms fairly closely. Let me suggest that we can divide education - I'm not referring to schooling - into three broad catagories. One has to do with how to do things, another has to do with deciding what things are worth doing and the third has to do with how one gets things done.

If you look at the first category - how to do things in the sciences and engineering - that is culture free for the most part. If you talk about the second phase - how to learn what things are worth doing - you are talking about a heavily culture bound process that is motivated to a great extent at the undergraduate level by the national concerns in any undergraduate educational system to inculcate individuals into that particular culture and into a scientific or engineering culture. At the graduate level, certainly, when one enters the culture of physics or the culture of mathematics or the culture of chemistry, one learns, if one is lucky, to have good taste in choosing problems, and to decide what is worth studying.

Finally, there is this issue of how to get things done. That's an infrastructure problem that is also heavily culture bound and that one usually learns when one leaves the university and goes out into industry and tries to figure out how to get things going.

When we talk about American graduate education in science and engineering for foreign students, it's that third component that very often is just nowhere in the process, and this raises some difficult questions. One of the most difficult ever brought to me as a graduate dean, several years ago, was from a young Iranian student in mechanical engineering who came into my office and asked what he was to do with his education after he finished. I misheard that question through my own particular set of filters and thought he was asking me a question about the relevance of American graduate education. When I started to answer that question, he said, "no, no, that's not what I asked you." He said he was delighted with the education he was getting but still did not know how he was supposed to use this terrific education. That's a major issue in graduate education in science and engineering.

Let me mention another. We've talked a lot today about data having to do with jobs for foreign scientists and engineers. It has always been my impression that the chemical industry has been a heavy hirer at the Ph.D. level but that the engineering industry has not been as interested in hiring doctorates as it has been in hiring people at the bachelor's level. That seems to have changed greatly recently, particularly in some industries falling under the general description of High Tech. There seems to be a movement of basic research into those industries where there is a shorter period of time between the idea and the development, and a need for those industries to hire more Ph.D.s.

The first sign that this was important and that there was an international aspect to it came with the ads that many large industrial companies began taking several years ago in national magazines like Time and Newsweek. There would be a multicolored double page spread talking about some scientific accomplishment that was being carried out in the company, always with a picture of Dr. X who, nine times out of ten, was not, by appearance anyway, an American national. The person could, of course, have been a citizen or even an American national.

The heart of the mythology has changed. We are now very happy to have foreign students but not necessarily happy because they're enhancing the cultural life of our campuses. We're happy because they're keeping our industry and, in many cases, our graduate schools, particularly in engineering, alive. The justification has turned around, creating a kind of revisionist picture of graduate education in science and engineering.

In looking at some of the issues relative to foreign graduate students in science and engineering, my own experience is that I almost never hear of problems dealing with technical competence. Almost all of the problems turn out to be related to language or culture. Let me very briefly mention some of them. At state universities, the so-called foreign teaching assistant issue is a major problem. In my own particular university, located in the state capitol, it gets even worse. When you have foreign students teaching elementary mathematics to American students who, at 18 or 19 years old, can't add fractions, you have, in addition to a language problem, a cultural gap in trying to determine educational baselines. That's just disasterous.

Secondly, there is a problem of course pacing having to do with a large percentage of non-English speaking students in a class who are having difficulty understanding the instructor. The pace of the course, then, can begin to slow down as the percentage of foreign students with language problems increases. A problem almost never discussed has to do with writing. If you are a faculty member in a department that happens to have six students reaching the dissertation stage and none of them is a native writer of English, you might complain to the Chairman about the large number of foreign students in the department. Although it is a real problem, faculty are reluctant to do the natural thing and have their graduate students take remedial writing programs. This would conflict with the faculty desire to have their students in the laboratory.

Finally, my last point is something Michael Nacht discussed earlier. I don't think it is so much an "absence of decision" as a plethora of decisions at a variety of levels. Years ago I noticed that there were very few foreign students in a department in which I would have expected to find many more. I found that the answer was that there was a senior faculty member involved in the initial screening and writing of letters to applicants for degrees who felt personally that foreign students from certain countries should not be in graduate education in that particular discipline and was rejecting those applications out of hand. During the Iranian crisis, in a number of universities, it was not uncommon to have individuals in the Admissions Office, not academic personnel, simply throwing away applications from certain parts of the world. That's idiosyncratic: it has nothing to do with university policy. However, individual faculty members, department chairmen, deans, or presidents may have a certain idea of what American foreign policy should be or what development should be in a given country and admissions decisions and educational decisions relating to curriculum and program may be based on those ideas.

Scholarships and research, like scholars and researchers, have always been international, and are likely to continue that way. Internationalization needs fostering and nurturing if it is to flourish.

Roberta Hall, Project on the Status and Education of Women, AAC

Foreign Faculty and Graduate Students: How Do They Affect the Learning Climate for Women

The comment made by our previous speaker about "the problem of simply putting foreign students and American students in the same lab and expecting things to work out" is certainly true. However, it is freqently even more of a problem for women students than

for students in general. I would like to examine briefly what our Project has called "climate problems": issues concerning how women are actually treated in the classroom, in the lab and elsewhere, in their interaction with both faculty and with other students. What we've found is that there are a number of problems which are often greatly exacerbated for American women when they deal with foreign faculty and foreign students.

Let me just mention some of the general kinds of issues we've identified in work on climate. Essentially we've looked at ways in which women students are often treated differently from men students. (In some measure, this also applies to women faculty.) First, there are overt ways in which women may be singled out on the basis of sex. For example, medical school slides still feature the nude woman in red heels - and she's still wearing the same pair of shoes. Some faculty still make sexist and disparaging remarks about women. These kinds of things are all pretty obvious - although their continued prevalence may come as something of a surprise.

Much more difficult to identify and change are subtle faculty behaviors by which women are ignored, overlooked, made to feel invisible. These are behaviors such as using classroom examples in which the professional is always the "he" and the woman is always the client or the patient; addressing the class as if there simply were no women present with a question such as "When you were a boy..." or "Suppose your wife..."; making eye contact with male students after asking a question as if only men were expected to respond; interrupting women more often than men; spending more time with men students in labs and in informal interchanges.

In our own culture, these problems grow out of the ways in which we perceive and evaluate women. They are part and parcel of the way we interact as men and women in the larger society where expectations are different, and often lower, for women than for men; where women are seen as inherently not being as capable as men in many areas. As I said this is a general problem.

However, when I've discussed our climate papers on campuses, particularly at technical institutions, large numbers of women students raised these issues specifically in relation to male foreign faculty and graduate students in non-traditional fields. Certainly, climate problems may be greatly exacerbated when male faculty and graduate students come from countries where women by statute or custom have a very restricted role. At the extreme, there are some cultures where women are perceived as property, where women are denigrated or defined only in terms of their sexual role. Therefore, some male faculty and graduate students may have a great deal of difficulty in perceiving or treating women students as anything but inferior intellectually, and as sexual objects. In other cultures there is simply a great separation between men and women in the social and educational systems so that, by and large, men are not exposed to women in educational or professional contexts and may be uncomfortable in dealing with women as students or colleagues. The disproportionate number of foreign students who are male is, in many ways, a symptom of this kind of problem: women simply are not considered in their own countries as candidates for foreign study.

There are also, of course, many different cultural norms governing physical distance, touching, appropriate kinds of contacts and so forth. In many instances, foreign faculty may be unfamiliar with some of the legal issues in the United States concerning sexual harassment and related issues. Institutions may find themselves held liable if foreign faculty behave inappropriately toward women students and women colleagues.

Moreover, in many cultures there is no longstanding or popularly known Women's Movement, so that many of the issues we take for granted and are sensitive to, are simply

issues which have never been raised. And I think, too, that there may be something of a misperception about our own culture on the part of some foreign students and faculty: the "macho, cowboy image" of the strong silent (or violent) type who sweeps women - willing or not - off their feet and into the sunset.

Let me give you just a few examples of the problems women students have raised. There have been instances in which foreign faculty have all but refused to work with women graduate students, particularly in scientific and technical fields. In one of these instances, a woman needed a particular research experience. She was in a highly technical area at a high graduate level. There was essentially only one person on the faculty with whom she could work. That person, a foreign male faculty member, discouraged her in every way possible from working with him. She persisted anyway, and became a member of his lab team, where she was continually ridiculed by him. As is not unusual, his attitude "rubbed off" on the male students in the lab, who decalibrated the equipment she was using and made it difficult in other ways for her to complete her work successfully. The woman eventually transferred to another lab but she lost a year's work, a chance for a recommendation, and the opportunity to work in the area of greatest interest to her.

Often women undergraduates find that denigrating comments and sexist jokes are the norm in classes taught by male foreign faculty. I've found that frequently women students will recognize that there is a cultural problem involved; however, this has led them, as they put it, to "just give up." They say it is clear that the person comes from a culture where there is no respect for women, but they have to take his course so there's nothing they can do. However, they are not comfortable with the situation, and some transfer to other fields, to other majors, or to other institutions.

There is also the problem of informal interchanges, where so much of what is learned goes on. This is a problem for women students in general in working with faculty (particularly male faculty) but it is often even more of a problem for women in dealing with foreign faculty. For example, if a woman graduate student takes the initiative to be on a first name basis with a male foreign faculty member, he may be very much insulted. Or he may misread her intentions and take her actions as a "come-on."

It is essential that institutions take an active role in recognizing these climate problems and dealing with them. Indeed, institutions cannot just presume that everything will work out on its own. There should be some kinds of mechanisms on campus, both formal and informal, through which women students and faculty can raise these issues. For example, climate issues can be included on faculty evaluation forms with questions such as "Does the professor treat students of both sexes fairly?" or "Does the professor use sexist humor or make disparaging comments based on sex?" Most importantly, for the purpose of prevention, institutions should hold a special orientation for foreign faculty and for foreign graduate students, including all research assistants and teaching assistants, in order to raise their awareness of these issues and provide them with ways to make their classrooms and labs more equitable. Two papers, "The Classroom Climate: A Chilly One for Women?" and "Out of the Classroom: A Chilly Campus Climate for Women?" developed by the Project on the Status and Education of Women of the Association of American Colleges, have been used on many campuses to do just that, and can easily be adapted for use with foreign faculty and graduate students.

Maurice Mountain, Consultant

Foreign Students, Technology Transfer and National Security

I'm afraid there is very little I can contribute in the way of solutions to the problems discussed by the other speakers or even very little I possess in the way of relevant knowledge. But like the doctor who didn't know what was the matter with the patient but could prescribe something to cause fits since he knew how to cure those, I want to talk with

you about a problem on which I do have some knowledge and that is foreign students and the export of U.S. technology from the standpoint of our national security.

First of all, I think we all will agree that there are legitimate national security concerns about the flow abroad of technology and, of course, I mean by technology the knowledge of how to produce things which have military significance. The export from the U.S. of technology of this sort has been restricted in peacetime since the Export Administration Act of 1949. However, little attention was paid, in the past, to the mechanisms by which technology can be transferred. Most of the focus was on technical assistance contracts and turnkey plants. These clearly did transfer technology. But it wasn't until 1972 and the years immediately thereafter - the era of detente when we began to have Russian visitors to the tune of 2,000 a year - that we started to wonder about the role of foreign students. When we discovered that many of these "students" were 45 year old intelligence officers or people who already had such skills they could hardly be called students, we became concerned about what was happening to our export control of militarily significant technology.

This led to the Defense Science Board study, known later as the Bucy Report for J. Fred Bucy of Texas Instruments who headed it. One of the notable things about that report was that it outlined several mechanisms of technology transfer. Most importantly it pointed out clearly that technology transfer took place most effectively under conditions where competent people could associate and exchange information on a person-to-person basis. And the longer the association lasted and the greater the competence of the people involved, the more technology could be transferred.

This is the basis for current governmental concern with the transfers taking place in academic institutions. The fact that there are foreign students spending years in close association with our top people and acquiring, not just science but also technology of military value, poses a serious problem. But it is not the only one. Another is that a lot of information was made available to foreigners in the U.S. in published documents and academic meetings. To deal with this latter problem the law now provides that the Department of Defense can deny publication in the United States of unclassified data which would be controlled by the Export Administration Act or the International Traffic and Arms Regulations, if such data were to be exported outside the country. Efforts are also being made to control the access of foreign students in the U.S. to such data.

This could result in quite an incursion into the realm of academic freedom if it were not for the fact that a strong effort is being made - and one I think will be crowned with some success - to find a way to divide what is purely science from what is technology. This is being done with the assistance of a great many people in the academic and industrial worlds. As of now, it seems likely that scientific research, including basic scientific research where foreign students are involved, will not be affected. However, research not at the basic level, research close to technology, and specifically identified technology will probably be barred to foreign students. Such action is undesirable in many ways and may be painful for some but there are costs for everything and one must recognize that security has its costs.

Let me conclude by noting, as someone earlier today pointed out, that the interests of government, industry and academe are getting closer and closer together and their labors becoming more and more integrated in research contracts and similar undertakings. I think this calls for all three elements to work together to solve the very difficult problems of technology export control where foreign students are involved. Each will probably have to be willing to give up some of the privileges which they have long been accustomed to having or think they should have. As a former member of the Department of Defense and a long-time observer of the government scene, I have every reason to believe they will.

Robert Morgan, Washington University

Study of Foreign Engineering Students

Let me say something about policy issues first. The April 1984 issue of Engineering Education has an article entitled "Engineering Education and the International Student: Policy Issues," by Elinor Barber and myself which summarizes some of them. I want to comment on a couple of things I've learned here which I think are very important for policy. Dr. Finn's study provides a lot of valuable information and sheds much light on the issues. I'm struck by his actually having a number, based on what looks like some solid analysis, of the percentage of engineering doctoral students who stay in the U.S. and don't go back to their countries. It's something like 62% when computer science is included in the engineering total. Another striking finding is that the growth in the workforce has been in naturalized citizens: it hasn't been in people on temporary visas. Thus, we're dealing with U.S. students, not aliens. That, it seems to me, is quite significant. We've had U.S. citizens who have come here from other countries through the years; I'm a second generation American myself. In a sense, the process is continuing.

I was interested in Mr. Doyle's comments about depressed university salaries compared with industry. I've always wondered why my salary was depressed. I've worked at universities all my life. Salaries were depressed 30 years ago but for some crazy reason, I decided to go into teaching anyway. Mr. Doyle's theory that the recent influx of foreign nationals is depressing engineering faculty salaries is interesting but it may not be borne out historically. Other factors may be at work.

I'm a little worried about some of the comments of the last speaker, Dr. Mountain. Being in engineering, I know engineering faculty and schools are very interested in the new interdisciplinary research centers supported by the National Science Foundation in important areas such as robotics and biotechnology. However, I wonder how we handle a situation in which over 50% of our engineering doctoral graduates are from other countries. What balance do we strike between open scientific and technical communication on one hand, and restrictions on access and communication in the name of national security on the other? Doesn't open communication contribute in no small way to our national security?

I want to talk briefly about a study that is just getting underway, supported by the National Science Foundation. The principal investigator is Elinor Barber of the Institute of International Education. I'll be working on this study, which will focus on the impact of foreign students, primarily at the graduate level, on engineering education.

We're going to look at four main engineering disciplines: electrical, chemical, civil and mechanical. We will carry out two surveys, one of engineering department chairpersons and one of engineering faculty. We plan to survey all 600 to 700 of the chairpersons. We'll sample about 1100 to 1500 of the faculty. We hope to separate out facts from judgments or opinions. We're going to try to find out how the quality of foreign students compares with that of U.S. students. In this regard, we're a bit leery of GRE scores; some engineering departments don't think they are good indicators and some don't even bother to use them. We'll also be concerned with how decisions are made in such areas as admissions and financial aid. We'll try to find out about the performance of foreign graduate students as research and teaching assistants and, also, about possible restrictions placed on foreign students on some campuses. We'll report the results in aggregates with no individuals or institutions identified; we will use a small number of categories to classify universities as large or small; public or private, etc. Our main problem will be how to get a decent response, how to keep the questionnaires from being dropped into the wastebasket. We hope to get the questionnaires out in the fall of 1985 and have some results to report next summer. What we're trying to do is get better information about the impact of foreign graduate students on U.S. engineering education than the anecdotal type that goes around.

Discussion

John Hamblen, University of Missouri-Rolla

I would like to follow up on a couple of things Jack Doyle mentioned. I've been looking at my own salaries over the years compared with some brothers who went directly to the factory. I didn't go to exact computations but I think I'm about to catch up. The other point is that in computer science universities are competitive with industry. It isn't that industry is hiring them away but, rather, that there aren't enough being produced. We are competitive and that has skewed our faculty salaries compared with other departments.

Richard Wilcox, U.S. Arms Control and Disarmament Agency

I would like to add to that. This question of economics peeps just under the surface on all the other fine, cultural factors to be considered. It's been my experience that that there are very few faculty members, at least at the associate and full professor level, whose sole income is that faculty salary. In fields like computer science and engineering, they are usually doing quite a bit of consulting or they have a company on the side or they are on contingency fees with consulting firms and so forth. In fact, I remember a conversation I had with a faculty member at Case Western Reserve some years ago. I was asking him about problems with recruiting and he said there was no problem. He said Case could guarantee a match with industry salaries through the addition of consulting fees to faculty salaries. I'm not sure that low faculty salaries in the shortage fields are as serious a problem as has been suggested. Now the sacrifice the graduate students make by delaying entry into the workplace might well be a serious one. That's one the foreign students don't seem to face to the extent the American students do.

Jack Doyle, Institute of Electrical/Electronic Engineers

I wouldn't think there would be a problem finding out more on the subject. I think some of the salary surveys, if not most of them, not only ask for salaries but ask for total income. There are data available.

Jules LaPidus, Council of Graduate Schools

At the risk of sounding academic, I have to say that I think it's a mistake to deal with consulting income as discussed because faculty members are encouraged to consult in order to enhance their abilities as faculty. That they might get paid for it really isn't part of the issue. I think this is an area we should avoid or face head-on and talk about in other terms.

Richard Wilcox, US ACDA

I would agree that it's not a simple issue at all but I think it is a significant factor. Can we pursue that before going on to other questions?

Alan Fechter, National Research Council

Are we losing faculty to industry? The National Science Foundation data show that, while there is very little flow either way, the net flow is toward industry. I think the real problem, as identified by others, is the salary foregone in going to graduate school and the lack of incentive for engineers to get Ph.D.s.

Other Comments

There were comments from the floor on engineers' need to do rather than to know and it was pointed out that some of the best students are hired even before obtaining a bachelor's degree. Jack Doyle of IEEE reminded the participants that two out of three foreign nationals studying engineering in this country go on to graduate school. Jules LaPidus noted that there is too much done on a short term basis - he used the Sputnik years as an example - in science and engineering and that there is a need for more long term thinking. Gilbert Brown, Lowell University, talked of boom and bust cycles and how these cycles affected choices of graduate school versus immediate entry into the job market. He noted that it is hard to keep people in school when there are numerous and exciting job opportunities. The opposite is true in a tight job market. William Sangster, Dean of the College of Engineering at Georgia Tech, suggested that a factor not discussed is that better research experience is now available in industry than in academe.

Shirley Malcom, American Association for the Advancement of Science

I would like to say that in focusing on this particular tree - the international flow of talent in science and engineering - I think we may have lost sight of the forest. For in many cases, our problem may not be what is happening with foreign students entering as much as what is happening with our own students and their behavior. If that is indeed the case, we must ask "why?" If it is a matter of competing for slots, for example, in a graduate department which is capped, and if our students are not competing well, that says something about our educational system. It says that we need to pay more attention to what is happening at the front end of the process as well as at later stages. I appreciated the remark someone made on the crisis mentality we have allowed to develop. This lulls us into not dealing with the educational issues on a long-term, continuing, sustained and focused basis. We want to solve the immediate problem as opposed to the problem that has always been there: the problem of providing a high quality education, enabling our students to do whatever it is they may want to do.

There are questions which must be asked. For instance, can we depend on the foreign students continuing to bolster our own infrastructure? Can we be guaranteed that our country will continue to be the place of choice for foreign students, or will the emphasis shift as it has in the past? Another piece of that picture is the changing demographics. Pestilence, disease and war may take some out, but only immigration is going to add any in, because our student body is declining.

Moreover, the student body we have to educate and utilize does not look like the post-Sputnik student body. It's much more minority: we're talking about school systems that are 35% minority. In some of the states heavily dependent on high technology, such as California and Texas, school systems are approaching an equal majority/minority status. Consequently, if we don't start to deal with the overall educational pattern and see the interconnectedness between our school policies here and the graduate student situation, which is just a reflection of the larger sets of decisions or non-decisions that have been made with regard to how we educate our students, I think we're going to miss the point.

Charles Falk, Consultant

Conference Summary

Trying to summarize the views expressed at this conference is not easy since participants have revealed so many nuances and expressed so many points-of-view. There are many directions from which one can approach the foreign scientist and engineer issue.

There are also many valid concerns, but these concerns are sometimes only those of special interest groups. Thus, when analyzing the issue from a national policy point-of-view, the first question to be answered is whether a concern is important to the nation as a whole.

One important feature stands out - the danger of overgeneralization. This point was emphasized indirectly many times with repeated pleas to have data disaggregated to a greater extent so that one can check whether the characteristics attributed to a group really apply to all its sub-components. Generally, in the case of foreign scientists and engineers they do not! There are two specific dangers associated with overgeneralization: credibility problems when either exceptions are not taken into consideration or characteristics of a large sub-component are attributed to the aggregated total; and ineffective problem solutions, when those proposed do not recognize the complexities of the structure.

In discussing this issue it is important not to lose perspective. Foreign scientists and engineers represent only about three percent of the U.S. science and engineering labor force. In assessing the growth of this group one can note that the numbers are increasing at a rate which some may consider to be high, but one also has to remember that this is a growth of a relatively small proportion.

The question of the effects of foreign scientists and engineers on the demand-supply balance in the United States seemed to be one of the major issues underlying the discussions of this conference. Foreign nationals are an additional source of manpower which acts as a labor reservoir for U.S. universities and industries. However, there is a question as to whether we are becoming too dependent upon this reservoir. Are the positive aspects of this cushion against labor force imbalance outweighed by an increasing dependence on a foreign influx? Furthermore, has this foreign influx put American students or working scientists and engineers at a disadvantage? It was pointed out that at the baccalaureate level the labor force entry of foreigners is not a problem. In not a single technical professional field do foreign citizens account for more than 5% of the annual production of baccalaureate degrees from American universities and colleges. At the masters and doctorate level there may be an evolving problem in some fields, such as engineering and computer sciences, where the proportion of foreigners among new graduates can be as high as about 50%. It must, however, be remembered that most of these foreign graduates return to their own country.

The question was asked whether the foreign student population was affecting the proportion of U.S. baccalaureates entering graduate study in science and engineering. The consensus of the meeting seems to be that the decreasing number of U.S. S&E graduate students seems to be more related to an excellent job market which attracts students at the baccalaureate level - especially in engineering.

Another issue discussed was technology transfer due to the return of foreign students to their native country. Like many of the other issues raised, this one has two sides. On the one hand, many believe that such technology transfer is good for both the American economy, since it is likely to lead to greater high-technology exports, as well as for the economy of the recipient country, since it introduces productivity enhancing processes. On the other hand, such transfers of know-how can have national security implications and thus raise negative concerns.

The issues discussed up to now are primarily of a national character. There were others which had more of a regional or sectoral flavor. Education, its financing and process, was one of these. To what extent do and should taxpayers pay for the education of foreign

nationals? Unquestionably, state support of land grant institutions and federal support of research assistants both provide such support. The reluctance which is sometimes experienced to provide or collect data on foreign students is due in part to concerns about the impact of such information on state and federal laws and regulations. Academic institutions worry that they may lose financial support as a result of such data revelations. But there is another aspect of the academic funding issue. By admitting foreign students, institutions receive additional tuition dollars. This raised the question to what extent academic institutions try to keep up enrollments by recruiting foreign students and whether through this practice they restrict the education and advancement of the American students? Possible operational educational problems mentioned included the need to modify courses to accomodate foreign cultures and needs and language problems which can affect the content of courses as well as their presentation by foreign teaching assistants. However, benefits from foreign student participation, such as the broadening of horizons of American students, were also pointed out. Finally, the question of admission of foreign students to U.S. academic institutions as an instrument of foreign policy was also raised and the observation was made that students returning to their native countries make good ambassadors.

With respect to industrial impacts of foreign scientists and egnineers in the workforce, several important questions were raised. The most prominent one was industrial dependence on foreigners, especially during periods of manpower shortages. The view was expressed that for some sub-specialities, such as industrial engineering, many industries were very dependent on a foreign influx. Concerns were expressed that in view of this there were too many difficulties experienced in the hiring of these people due to state and federal regulations. Of course, related to this issue are some of the national security and opportunity-for-Americans issues mentioned previously.

In summary, the policy concerns brought up at this meeting tended to concentrate on immigration laws, hiring regulations, federal and state direct and indirect financial support of foreign students, educational side-effects of foreign student participation, and hiring practices and utilization of foreign scientists and engineers. There was a consensus that more clear-cut, overt, federal, state, and institutional policies are needed to deal with these issues.

With respect to data, its function is, of course, to provide objective information useful in the resolution of these issues. Two major data gaps were identified. The first involves the lack of information on the extent, nature and magnitude of financial support provided to foreign students. A limited amount of highly aggregated data exists, but different and much more disaggregated information was called for. It was pointed out that, since the foreign student population represents only a small proportion of all students, such disaggregation would require considerably larger samples and this would be expensive.

The second identified data gap consists of information on the utilization of foreign scientists and engineers in the U.S. labor force, including information on what happens to those that come in through the immigration route and to those that graduate from American universities and colleges. It was pointed out that some data of this type is currently being generated. However, it is being developed from the NSF/Census 1982 Postcensal Survey and thus reflects only one specific point in time. Means have to be found to collect such information during the 1982-92 period, since waiting for the 1992 Postcensal Survey leaves a decade of no current information.

Overall, the seminar made it very evident that the foreign scientists and engineer issue, whether it relates to students or those actually employed in American institutions, has many facets. Furthermore, most of these involve positive as well as negative factors and it is

very difficult to determine which one is dominant. In conclusion, the conference was reminded, however, that the United States has in the past always freely admitted foreign scientists and engineers to its shores and that generally it has greatly benefitted from this practice.

THE INTERNATIONAL FLOW OF SCIENTIFIC AND TECHNICAL TALENT: DATA, POLICIES AND ISSUES

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